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MATHÉMATIQUES

SUR LA THÉORIE DES INTÉGRALES DE STIELTJES-RADON ET LES ÉQUATIONS INTÉGRALES

Par N. GUNTHER, membre correspondant de l'Académie

1. Soient donnés un domaine borné (Ω) et un corps (C) de domaines appartenant à (Ω). Soit donnée une fonction moyenne $u(\omega)$ à variation bornée et à valeurs positives ayant le corps (C) pour corps de continuité [1].

À la fonction $u(\omega)$ on peut faire correspondre une fonction d'ensembles $u(e)e$ définie dans un certain corps (U) d'ensembles (e) [2]. En désignant par $\overline{u(e)e}$ la borne inférieure des sommes $\sum u(i_n)i_n$, où les (i_n) sont des intervalles appartenant à (C), sans points intérieurs communs, qui couvrent (e), on dit que (e) appartient à (U), si $\overline{u(e)e}$ ne diffère pas de $\overline{u(o)o} - \overline{u(o-e)(o-e)}$, (o) étant un ensemble ouvert contenant (e); on pose dans ce cas

$$u(e)e = \overline{u(e)e}. \tag{1}$$

La fonction d'ensembles $u(e)e$ est absolument additive; le corps (U) contient tous les ensembles mesurables (B); si l'on traite (ω) comme un ensemble de points, $u(\omega)\omega$ est égale à la valeur de la fonction moyenne donnée, si (ω) appartient au corps (C). Si

$$v(\omega) = u_1(\omega) - u_2(\omega) + i[u_3(\omega) - u_4(\omega)], \tag{2}$$

les fonctions $u_k(\omega)$ étant additives, à variation bornée et à valeurs positives, faisons correspondre à $v(\omega)$ la fonction

$$v(e)e = u_1(e)e - u_2(e)e + i[u_3(e)e - u_4(e)e]. \tag{3}$$

Elle est définie dans le corps (V), qui est la portion commune des corps (U_k) $(k=1, 2, 3, 4)$.

2. Soit donnée une fonction de points (x) appartenant à (Ω):

$$f(x) = f_1(x) + if_2(x), \tag{4}$$

où f_1 et f_2 sont mesurables (B) et bornées. Supposons que les valeurs de $f_1(x)$ et $f_2(x)$ sont comprises entre l_0 et $l = l_n$; intercalons entre l_0 et l des nombres $l_1, l_2, \ldots, l_{n-1}$ et désignons par (e_k), (e'_k) les ensembles de points pour lesquels on a respectivement

$$l_{k-1} \leqslant f_1(x) < l_k, \quad l_{k-1} \leqslant f_2(x) < l_k. \tag{5}$$

Posons $(e_{ks}) = (e_k \cdot e_s)$. Les sommes

$$\sum_{s=1}^{s=n} \sum_{k=1}^{k=n} (l_{k-1} + il_{s-1})\, v(e_{ks})\, e_{ks} \tag{6}$$

possèdent une limite déterminée quand $n \to \infty$, les différences $l_k - l_{k-1}$ tendant uniformément vers zéro. Nous désignons cette limite par

$$\int_{(\Omega)} v(\omega) f(x)\, d\omega \tag{7}$$

en lui donnant le nom de l'intégrale de Stieltjes-Radon. On a

$$\left| \int_{(\Omega)} v(\omega) f(x)\, d\omega \right| \leqslant \int_{(\Omega)} V(\omega) |f(x)|\, d\omega < MV(\Omega)\,\Omega, \tag{α}$$

où M est la borne de $|f(x)|$ et $V(\omega)$ — la variation moyenne de $v(\omega)$. On a:

$$\int_{(\Omega)} v(\omega) f(x)\, d\omega = \sum_{k=1}^{k=n} \int_{(e_k)} v(\omega) f(x)\, d\omega = \sum_{k=1}^{k=n} \int_{(\omega_k)} v(\omega) f(x)\, d\omega, \tag{β}$$

si les domaines (ω_k) appartiennent au corps (C), les ensembles (e_k) et les domaines (ω_k) formant une division de (Ω) en ensembles, respectivement en domaines, partiels;

$$\int_{(\Omega)} [f(x) + F(x)]\, v(\omega)\, d\omega = \int_{(\Omega)} v(\omega) f(x)\, d\omega + \int_{(\Omega)} v(\omega) F(x)\, d\omega; \tag{γ}$$

$$\int_{(\Omega)} v(\omega) f(x)\, d\omega = \int_{(\Omega)} v(\omega) F(x)\, d\omega, \tag{δ}$$

si les fonctions $f(x)$ et $F(x)$ diffèrent seulement aux points d'un ensemble (e_0), pour lequel on a $V(e_0)\, e_0 = 0$; enfin, si $f(x)$ est continue, l'intégrale (7) ne diffère pas de l'intégrale de Stieltjes, utilisée dans mon mémoire (1).

3. Si la fonction $f(x)$ est positive mais n'est pas bornée, posons

$$f^{(n)}(x) = f(x), \text{ si } f(x) \leqslant n;\ f^{(n)}(x) = n, \text{ si } f(x) > n; \tag{8}$$

prenons pour la définition de l'intégrale l'égalité

$$\int_{(\Omega)} v(\omega) f(x)\, d\omega = \lim_{n \to \infty} \int_{(\Omega)} v(\omega) f^{(n)}(x)\, d\omega \tag{9}$$

en disant que $f(x)$ n'est pas sommable, si la limite n'existe pas. Si $f(x)$ est complexe et si

$$f(x) = \underset{+}{f_1} - \underset{-}{f_1} + i(\underset{+}{f_2} - \underset{-}{f_2}), \tag{10}$$

$\underset{+}{f_1}$, par exemple, étant égale à $-f_1$, si $f_1 < 0$, et à zéro, si $f_1 > 0$, posons:

$$\int_{(\Omega)} v(\omega) f(x)\, d\omega =$$

$$= \int_{(\Omega)} v(\omega) \underset{+}{f_1}\, d\omega - \int_{(\Omega)} v(\omega) \underset{-}{f_1}\, d\omega + i\left[\int_{(\Omega)} v(\omega) \underset{+}{f_2}\, d\omega - \int_{(\Omega)} v(\omega)\, \underset{-}{f_2}\, d\omega \right]. \tag{11}$$

Convenons de dire que l'intégrale (11) converge absolument, si l'intégrale

$$\int_{(\Omega)} V(\omega) |f(x)|\, d\omega \tag{12}$$

est convergente. Les assertions (β), (γ), (δ) restent valables pour les intégrales (11).

4. Soient $u(\omega)$ une fonction moyenne à variation bornée à valeurs positives et $f(x)$ une fonction mesurable (B). Convenons de nommer la fonction moyenne

$$f(\omega) = \frac{1}{\omega} \int_{(\omega)} u(\omega) f(x)\, d\omega \tag{13}$$

la moyenne mesurée de $f(x)$ et $u(\omega)$ — la fonction de mesure. La variation moyenne de $f(\omega)$ est égale à

$$\frac{1}{\omega}\int_{(\omega)} u(\omega)\,|f(x)|\,d\omega. \tag{14}$$

Convenons de dire que $f(x)$ est à carré sommable en cas de la convergence de l'intégrale

$$\int_{(\Omega)} u(\omega)\,|f(x)|^2\,d\omega. \tag{15}$$

5. Étant données les fonctions $f(x)$ et $F(x)$ mesurables (B) et une fonction moyenne $v(\omega)$, posons

$$w(\omega) = \frac{1}{\omega}\int_{(\omega)} v(\omega)\,F(x)\,d\omega. \tag{16}$$

Si les intégrales

$$\int_{(\Omega)} v(\omega)\,f(x)\,d\omega, \quad \int_{(\Omega)} v(\omega)\,F(x)\,d\omega, \quad \int_{(\Omega)} v(\omega)\,f(x)\,F(x)\,d\omega \tag{17}$$

sont absolument convergentes, on a

$$\int_{(\Omega)} w(\omega)\,f(x)\,d\omega = \int_{(\Omega)} v(\omega)\,f(x)\,F(x)\,d\omega. \tag{18}$$

6. Divisons (Ω) en domaines partiels (ω_1), (ω_2), ..., (ω_n). Soient données deux fonctions moyennes $\varphi(\omega)$ et $v(\omega)$. Si les sommes

$$\sum_{k=1}^{k=n} \frac{|\varphi(\omega_k)|^2}{u(\omega_k)}\,\omega_k \tag{19}$$

restent bornées, nous disons que $\varphi(\omega)$ est de la classe (H). Si les sommes

$$\sum_{k=1}^{k=n} \frac{\varphi(\omega_k)\,v(\omega_k)}{u(\omega_k)}\,\omega_k \tag{20}$$

ont une limite déterminée quand $n \to \infty$, les diamètres des domaines (ω_k) tendant uniformément vers zéro, nous donnerons à cette limite le nom d'intégrale de Hellinger en la désignant par

$$\int_{(\Omega)} \frac{\varphi(\omega)\,v(\omega)}{u(\omega)}\,d\omega. \tag{21}$$

On démontre: 1) si $f(x)$ est à carré sommable et si $f(\omega)$ est sa moyenne mesurée, on a

$$\int_{(\Omega)} \frac{|f(\omega)|^2}{u(\omega)}\,d\omega = \int_{(\Omega)} u(\omega)\,|f(x)|^2\,d\omega; \tag{22}$$

2) si $\varphi(\omega)$ est de la classe (H) et $f(x)$ à carré sommable, on a

$$\int_{(\Omega)} \frac{\varphi(\omega)\,f(\omega)}{u(\omega)}\,d\omega = \int_{(\Omega)} \varphi(\omega)\,f(x)\,d\omega. \tag{23}$$

Si le nombre n est assez grand, on a pour chaque $\varepsilon > 0$ l'inégalité

$$\left|\int_{(\Omega)} \varphi(\omega)\,f(x)\,d\omega - \sum_{k=1}^{k=n} \frac{\varphi(\omega_k)\,f(\omega_k)}{u(\omega_k)}\,\omega_k\right| < \varepsilon\sqrt{H}\sqrt{u(\Omega)\,\Omega} + g\sqrt{\varepsilon}\sqrt{H}, \tag{24}$$

dans laquelle H est la borne des sommes (19), g — une constante absolue, le nombre n ne dépendant pas du choix de $\varphi(\omega)$.

7. Envisageons l'équation intégrale

$$\varphi(x) = \lambda \int_{(\Omega)} k(\tau, x)\, \varphi(y)\, d\tau + F(x) \qquad (1)$$

dont le noyau $k(\tau, x)$ est assujetti aux conditions suivantes.

a) Une fonction de mesure $u(\omega)$ étant définie dans le corps (C), la fonction $k(\tau, x)$ comme fonction de (τ) est définie dans le corps (C_x) obtenu de (C) en rejetant les domaines ayant le point (x) sur leurs frontières. Elle est à variation bornée, sa variation totale $K(\Omega, x)\,\Omega$ étant comme fonction de (x) à carré sommable et mesurable (B). Il suit de cette définition, que $k(\tau, x)$ ne peut être infinie qu'aux points, où $K(\Omega, x)\,\Omega$ est infinie.

b) Le noyau $k(\tau, x)$ est hermitien, c'est-à-dire on a

$$k(\tau, \omega) = \overline{k(\omega, \tau)}, \quad k(\tau, \omega) = \frac{1}{\omega} \int_{(\omega)} u(\omega)\, k(\tau, x)\, d\omega. \qquad (2)$$

c) Sa variation moyenne $K(\tau, x)$ répond a l'inégalité:

$$\int_{(\Omega)} K(\Omega, z)\, \Omega K(\xi, x)\, d\xi < BK(\Omega, x)\, \Omega. \qquad (3)$$

Les noyaux $k(\tau, x)$ de mon mémoire [1] satisfont aux dites conditions.

Les conditions (a), (b) et (c) assurent: 1) l'existence des noyaux itérés $k_n(\tau, x)$, où

$$k_n(\tau, x) = \int_{(\Omega)} k_{n-1}(\tau, x)\, k(\xi, x)\, d\xi; \qquad (4)$$

2) les variations des noyaux itérés sont des fonctions à carré sommable, répondant à l'inégalité

$$K_n(\Omega, x)\, \Omega < B^{n-1} K(\Omega, x)\, \Omega. \qquad (5)$$

8. En désignant par $h(x)$ une fonction à module borné, introduisons la fonction

$$H(x) = \sum_{l=0}^{l=m} \alpha_l k_l(h, x), \quad k_l(h, x) = \int_{(\Omega)} h(y)\, k_l(\tau, x)\, d\tau, \qquad (6)$$

en supposant que $k_0(\tau, x) = \delta(\tau, x)$, $\delta(\tau, x)\,\tau$ étant égale à zéro ou à l'unité, suivant que (x) est en dehors du domaine (τ) ou dans son intérieur. On établit les égalités

$$\frac{1}{\omega} \int_{(\omega)} u(\omega) \left(\int_{(\Omega)} H(y)\, k_s(\tau, x)\, d\tau \right) d\omega = \int_{(\Omega)} H(y)\, k_s(\tau, \omega)\, d\tau; \qquad (7)$$

$$\int_{(\Omega)} H_1(x) \left(\int_{(\Omega)} k_s(\tau, \omega)\, H(y)\, d\tau \right) d\omega = \int_{(\Omega)} H(y) \left(\int_{(\Omega)} k_s(\tau, \omega)\, H_1(x)\, d\varphi \right) d\tau. \qquad (8)$$

Les égalités (7) et (8) étant établies, on démontre que (1) $k_s(\tau, \omega)$ possède le caractère hermitien et que (2), en convenant de désigner par $k_s(H, H_1)$ le premier membre de (8),

$$0 < k(H, \overline{H}) < B \int_{(\Omega)} u(\omega)\, |H(x)|^2\, d\omega. \qquad (9)$$

L'inégalité (9) étant démontrée, on peut appliquer à l'équation (1) tous les raisonnements de mon mémoire [1], car c'est seulement aux fonctions de la forme (6) que l'inégalité (9) est appliquée dans le dit mémoire, et suivant une remarque dans le paragraphe 9 du chapitre 5 de la seconde partie toute la théorie repose sur cette inégalité.

9. La fonction spectrale $\theta(\tau, \omega, m)$ étant construite et les formules:

$$\theta(h, h_1, m) = \int_{(\Omega)} h_1(x) \left(\int_{(\Omega)} \theta(\tau, \omega, m)\, h(y)\, d\tau \right) d\omega =$$

$$= \int_{(\Omega)} h(y) \left(\int_{(\Omega)} \theta(\tau, \omega, m)\, h(x)\, d\omega \right) d\tau, \tag{10}$$

$$\left| \theta(h, h_1, m)\, m \right| < \sqrt{\int_{(\Omega)} u(\omega)\, |h(x)|^2\, d\omega} \sqrt{\int_{(\Omega)} u(\omega)\, |h_1(x)|^2\, d\omega}, \tag{11}$$

$$\int_{(\Omega)} \frac{\theta(h, \tau, m)\, m \theta(\tau, h, m)\, m}{u(\tau)}\, d\tau = \theta(h, h_1, m)\, m, \tag{12}$$

$$\int_{(\Omega)} \frac{\theta(h, \tau, m)\, \theta(\tau, h_1, m_1)}{u(\tau)}\, d\tau = 0; \tag{13}$$

si les intervalles (m) et (m_1) n'ont pas de points intérieurs communs, étant établies pour les fonctions $h(x)$ et $h_1(x)$ à modules bornés, on peut démontrer que les intégrales

$$\int_{(\Omega)} \theta(\tau, \omega, m)\, h(y)\, d\tau, \quad \int_{(\Omega)} h_1(x) \left(\int_{(\Omega)} \theta(\tau, \omega, m)\, h(y)\, d\tau \right) d\omega \tag{14}$$

ont un sens, quand $h(x)$ et $h_1(x)$ sont à carré sommable et que les formules (10), . . . , (13) subsistent pour des fonctions pareilles. On en conclut, que les théorèmes sur le développement des fonctions, auxquels est consacré le chapitre 4 de mon mémoire, restent valables si la fonction est à carré sommable.

10. En prenant pour base la théorie des équations répondant aux conditions du paragraphe 7 et en appliquant le procédé, utilisé par T. Carleman dans son remarquable mémoire [4], on peut obtenir une théorie des équations intégrales plus générale que celle de Carleman, embrassant les cas, dans lesquels le noyau $k(\tau, x)$ et la fonction de mesure $u(\omega)$ ne sont pas éventuellement à variation bornée.

L'Université de Leningrad.

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PHYSICS

ON THE SENSITIVITY THRESHOLD OF A GAS RADIOMETER

By K. WULFSON

(Communicated by S. I. Wawilow, Member of the Academy, 9. X. 1938)

In the journal «Rev. of Scient. Instr.» a paper by Heiess (1) was published giving an account of the peculiar design of a gas radiometer. In that work the author comes to an altogether ungrounded conclusion to the effect that his radiometer is by far more sensitive than thermocells of the usual type. He draws this unwarranted conclusion from a comparison of the strain obtained upon an increase of the readings of this radiometer with the strain developed by a thermocell in a direct way. At the same time the essential question of threshold sensitivity remains open.

An attempt at the solution of this problem was first made by M. L. Veingerov (2). In his calculations this author unfortunately committed a mistake and accordingly arrived at the wrong conclusion that the sensitivity threshold of a gas radiometer equals $W_{\min} \approx 10^{-19}$ watts, which is by far lower than in the case with modern thermocells for which $W_{\min} \approx 10^{-10}$ watts (3).

In view of the fact that in his new work M. L. Veingerov again points to the considerably greater sensitivity of a gas radiometer, we deem it expedient to expound here in full the theory of the gas radiometer.

Let us examine the idealized lay-out of the construction of a gas radiometer, as represented in the figure. As a matter of fact, in his first work. M. L. Veingerov took his starting point in a similar scheme of a radiometer.

Radiation is admitted through an aperture closed by transparent window *1*. Being absorbed by gas *3* and also by a thin blackened plate *2*, this radiation produces heating, owing to which the gas expands and displaces piston *4*, performing work.

For calculating the work of the displacement of the piston M. L. Veingerov first made the assumption that besides gas pressure the piston is also acted upon by elastic forces which he, however, leaves out of account in the subsequent; for the calculation of work he makes use of the following expression:

$$A = p\,\Delta v = R\Delta T. \qquad (1)$$

This expression, however, fails to account for the gas pressure acting upon the piston from the outside. The motion of the piston is called forth by the difference between the outer and inner pressure, i. e. $p_0 - p$. Accor-

dingly, as the piston is displaced, this magnitude varies, wherefore to estimate the work it will be necessary to calculate the integral [3]:

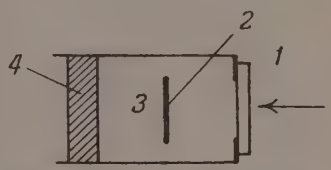
$$A = \int_{v_0}^{v} (p_0 - p)\, dv = S \int_{x_0}^{x} (p_0 - p)\, dx, \qquad (1')$$

where p_0 is gas pressure prior to heating (equal to external pressure), S — piston area, x — displacement of piston.

Expression (1) made use of by M. L. Veingerov gives, as will be shown below, a result differing from the correct one by a value of the order of

$$\frac{\Delta p}{p} \approx 10^{-10}.$$

The smaller the amount of radiant energy falling on the radiometer, the less the magnitude by which the piston becomes displaced. Measurements will be feasible only provided the displacement produced by the falling energy exceeds a definite number of times the fluctuational displacements of the piston caused by the thermal motion of molecules. Accordingly, in order to find the sensitivity threshold, it is necessary to equalize the displacement of the piston due to the heating of gas by radiant energy to the mean quadratic displacement called forth by fluctuations.



The mean quadratic displacement of the piston can be found, as is well known, from the condition that the average work of fluctuations

$$\bar{A} = \frac{kT}{2} \qquad (2)$$

(k is Boltzman's constant).

Expressions (1′) and (2) provide the possibility of computing the mean square of the displacement of the piston.

Expanding the expression under the integration sign in a series and confining ourselves to the first term, we find:

$$A = S^2 \frac{\partial p}{\partial v} \int_{x_0}^{x} (x_0 - x)\, dx = -S^2 \frac{\partial p}{\partial v} \frac{(x_0 - x)^2}{2}, \qquad (3)$$

whence

$$\overline{(x_0 - x)^2} = -\frac{kT}{S^2 \frac{\partial p}{\partial v}}. \qquad (4)$$

For the determination of $\frac{\partial p}{\partial v}$ we resort to equation of state * $pv = RT$, whence

$$\frac{\partial p}{\partial v} = -\frac{p_0}{v_0}. \qquad (5)$$

Substituting the value $\frac{\partial p}{\partial v}$ in expression (4), we find:

$$\overline{(x_0 - x)^2} = \frac{kTx_0}{Sp_0}. \qquad (6)$$

Let us now calculate the magnitude of the displacement of the piston called forth by radiation which heats the gas by ΔT. From the equation of state we find:

$$\frac{\Delta v}{v_0} = \frac{\Delta x}{x_0} = \frac{\Delta T}{T}. \qquad (7)$$

* We assume that the radiometer is filled with an ideal gas.

For determining the sensitivity threshold of the radiometer we compare Δx with $\sqrt{\overline{(x_0-x)^2}}$, whence

$$\Delta T_{\text{threshold}} = \sqrt{\frac{k}{R}} \cdot T_0, \qquad (8)$$

where R is a gas constant for the amount of gas comprised in the radiometer.

The amount of radiant energy necessary for heating the radiometer up to $\Delta T_{\text{threshold}}$ is determined by equality:

$$\Delta T_{\text{threshold}} = \frac{W_{\text{threshold}}}{F}, \qquad (9)$$

where $F = 4\sigma T_0^3 s + f$, σ — constant of radiation, s — surface absorbing radiation, f — coefficient determining loss of heat due to thermal conductivity and convection of gas.

If we are to take the utmost ideal case, when $f = 0$, i. e. when all the losses are reduced to reverse emission, then it will be easily possible to calculate the sensitivity threshold of a gas radiometer.

Assuming that the vessel with volume $V_0 = 5$ mm² * is filled with air under the pressure of 760 mm mercury column, we find with $s = 0.1$ cm²:

$$W_{\text{threshold}} \approx 5.0 \cdot 10^{-11} \text{ watts}.$$

The minimum amount of energy measured with an accuracy of up to 1% will be equal to

$$W_{\min} = 5.0 \cdot 10^{-9} \text{ watts}.$$

The latter value will be found to coincide by its order with the sensitivity of a thermocell calculated by Cartwright ([3]).

Taking now into account the hitherto omitted losses of heat on conductivity and gas convection, which losses exceed under ordinary conditions 5—10 times the losses on reverse emission, we might find that the sensitivity of the gas radiometer could not possibly be twice that of a vacuum thermocell (of equal inertia and receptive surface), but would in practice even be considerably lower.

In conclusion we intend showing that the ideal scheme of a gas radiometer as just considered presents the optimum conditions from the point of view of the possibility of measuring slight variations of temperature and consequently small light fluxes.

Let us assume that besides outer permanent pressure P_0, brought about either by a weight applied on the piston or by the pressure of the gas outside the radiometer, the piston is also acted upon by other forces, no matter be they elastic or quasi-elastic ones (unavoidable in the practical materialization of such a radiometer). In this case formula (1′) will assume the following appearance:

$$A = \int_{v_0}^{v} [p_0 - p + \alpha (x_0 - x)]\, dv = -S^2 \frac{\partial p}{\partial v} \frac{(x_0-x)^2}{2} + \frac{(x_0-x)^2}{2} \alpha S, \qquad (1'')$$

where α is the constant of an elastic or quasi-elastic force (in the case of a radiometer provided with a U-like barometrical tube $\alpha = 2\rho g$; ρ — the

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* In our numerical example we have diminished the volume of the radiometer as compared with the estimate of M. L. Veingerov, because the radiometer of the size indicated by that author would have possessed an inertia hundredfold that of ordinary thermocells.

density of the liquid filling the tube and g — the acceleration of gravity force). Equating $A = \frac{kT}{2}$, we find:

$$\overline{(x_0 - x)^2} = \frac{kTx_0}{Sp_0 + 2\rho g S x_0}. \qquad (6')$$

In calculating the displacement of the piston brought about by heating through incident radiation, allowance is to be made for the dependence of outer pressure upon volume:

$$p = p_0 + \frac{2(v_0 - v)\rho g}{S};$$

making use of equation of state $pv = RT$, we find:

$$\Delta x = \frac{\Delta v}{S} = \frac{R\Delta T}{p_0 S + 2x_0 \rho g S}.$$

Comparing Δx with $\sqrt{\overline{(x_0 - x)^2}}$, we obtain:

$$\Delta T_{\text{threshold}} = \sqrt{\frac{kTx_0 S(p_0 + 2\rho g x_0)}{R^2}} > \sqrt{\frac{k}{R}} \cdot T.$$

It will be seen from the above inequality that sensitivity to temperature and consequently to radiation falls with the appearance of elastic or quasi-elastic forces acting upon the piston. Thus, the scheme of a gas radiometer examined in the earlier part of this work is found to be the most advantageous.

The above calculations show that a gas radiometer, irrespective of design, fails to possess a sensitivity billion times as high as that of thermocells, as this has been claimed by Heiess and Veingerov.

All-Union Electrotechnical Institute. Moscow.

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PHYSICS

ON K. WULFSON'S ARTICLE «ON THE SENSITIVITY THRESHOLD OF A GAS RADIOMETER» (1)

By M. L. VEINGEROV (WEINGEROFF)

(Communicated by S. I. Wawilow Member of the Academy, 9. X. 1938)

In my paper entitled «Über die Grenzempfindlichkeit eines auf dem Prinzip des Gasthermometer beruhenden Radiometers» (2) I compared the external work (increase of potential energy of the piston raised), carried out by a gas heated by radiation, with the work, carried out in the case of the fluctuations of the piston's position. K. S. Wulfson compares the magnitude of the fluctuations of the piston's position with a displacement due to radiation. His method of calculation does not differ essentially from mine, both methods giving identical results. I obtained, however, an incorrect numerical result having erroneously assumed the external work, due to fluctuations of the piston's position, to be $\frac{1}{2}kT$, while in fact it is $\sqrt{\frac{C_p - C_v}{C_p}}\varepsilon$, where $\varepsilon = \sqrt{C_v kT}$ is the heat conducted to gas by means of fluctuations.

K. S. Wulfson obtained a correct numerical result without, however, clearly explaining in his paper the error I commited when solving the problem of sensitivity of the gas radiometer formulated by me.

My assertion that the gas radiometer must possess a much higher sensitivity than other indicators of radiation, owing to the fact that the portion of the heat supplied to the gas and converted into external work is $\frac{C_p - C_v}{C_p}$, is incorrect, since the fraction $\sqrt{\frac{C_p - C_v}{C_p}}$ of heat conducted by means of fluctuations is also converted into external work.

State Optical Institute.
Leningrad.

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PHYSICS

THE FORMATION OF ELASTIC TWINS DURING THE TWINNING OF CALCITE CRYSTALS

By R. I. GARBER

(Communicated by A. F. Joffe, Member of the Academy, 14. X. 1938)

It is commonly believed that twinning of calcite crystals begins with a gradual turn of the crystalline lattice, of the whole part being twinned under the shear stress. Only when this stress reaches a certain value and the lattice turns through a certain limited angle, a jump-like translation takes place, resulting in a new equilibrium position, under which the mirror image position in the twinning plane of the original crystal lattice should be supposed. Such a mechanism interferes, however, with the fact that the elastic strain (before the twinning in its common sense starts) has a very low value and, according to the determination made by W. Voigt (1) in 1899, is of the order of 10^{-3}. Since that time none of the numerous publications dealing with twinning was able to solve this problem (2).

We undertook the task to study the mechanism of twinning calcite crystals more closely, especially in the stage which precedes the formation of common residual twins. We have established that stresses even as low as 26 g per mm^2 produce elastic twins.

These elastic twins appear as tapered wedge-shaped flakes located in the twinning plane. In polarized light they look like dark wedges upon a bright crystalline surface (Fig. 1, *a*).

When turning the nickols, it was possible to ascertain that the elastic twins upon the dark crystal appeared like very thin and bright wedges.

These observations were made on prismatic specimens cut out of a calcite crystal in such a way that the basis of the prism coincided with the twinning plane. Two side faces of the specimens which were parallel with the direction of the twinning were polished as optical surfaces and examined under the microscope. Such a prism was fixed like a cantilever beam and a concentrated load was applied along the direction of twinning at a point of the specimen close to the clamp.

With such an arrangement, elastic twins were observed in the cross-section between the clamp and the load, that is in that portion where the shear stress is supposed to be equal to the calculated one.

In the course of these experiments it was observed that the first elastic twin appeared in the point where the concentrated load was applied. With the increase of the load the twin grew in length, becoming also somewhat broader in the direction of the twinning plane and remaining very thin, i. e. the twin maintains its form of a wedge-shaped flake lying in the twinning plane.

With a further increase of the load new elastic twins make appearance. They are located closer to the clamp, i. e. in such places where the presence of some bending moments may be supposed; these moments act in addition to the shear stress, the latter acting in each cross-section between the applied

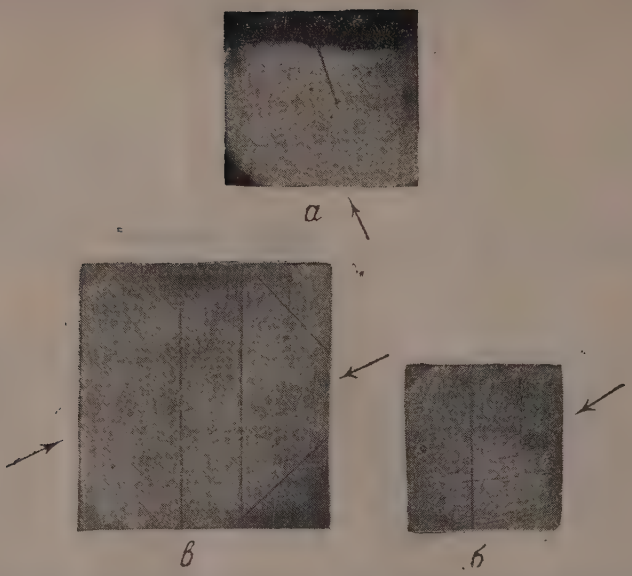

Fig. 1. *a*—an elastic twin in polarized light. The crystal is bright, the twin resembles a dark wedge-shaped fissure. The plane of twinning cuts the surface of the picture vertically and coincides with the twin (x 18). *б*—a break («fault») of the scratch which intersects an elastic twin (x 225); *b*—a break («fault») of the scratch which intersects a common twin (x 225).

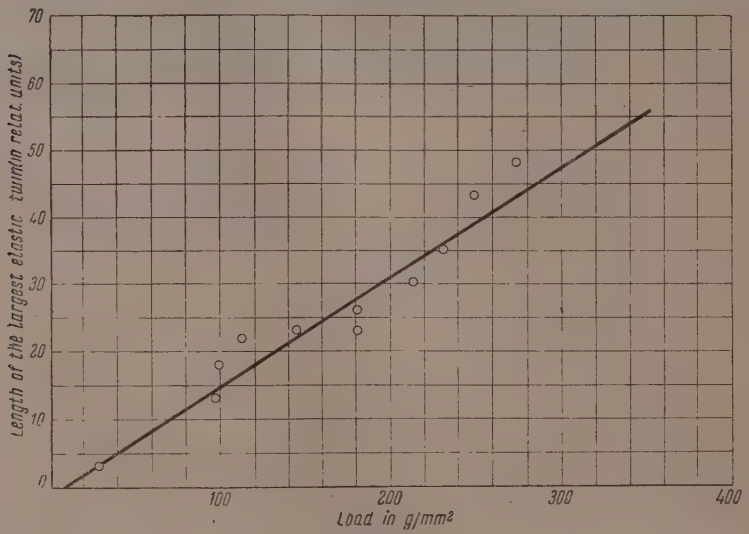

Fig. 2.

load and the clamp. However, in this case we cannot consider the influence of the bending moments as ascertained.

The results of one of such experiments are given in the table and in the diagram (Fig. 2), which shows that the size of the elastic twin is approximately proportional to the applied load.

Shear loads in g per mm²	Length of elastic twins observed (In relative units)					Total length of all elastic twins	Notes
	a	*b*	*c*	*d*	*e*		
—	—	—	—	—	—	—	Before the application of the load no twins
114	22	—	—	—	—	22	—
—	—	—	—	—	—	—	After complete removal of the load the twin disappeared altogether
22.8	3	—	—	—	—	3	The twin *a* reappeared
68.3	13	—	—	—	—	13	—
91	18	—	—	—	—	18	—
137	23	—	—	—	—	23	—
182	26	13	—	—	—	39	The twin *b* was observed
182	23	13	12	—	—	48	Twin *a* shortened and *c* appeared without variation of the load
182	8	6	5	23	—	42	Twins *a* and *c* shortened and *d* appeared without variation of the load
205	4	2	8	30	3	47	Twin *c* appeared
228	4	—	9	35	3	51	Twin *b* disappeared
250	5	—	8	43	8	64	Twin *e* has a swell at its extremity
274	—	—	9	[illegible]	5	62	Twin *a* disappeared
296	—	—	—	—	—	—	A residual twin was formed at the point of *d*, the other disappeared; the stress has fallen down to 182 g/mm²
—	—	—	—	—	—	—	After complete removal of the load only one residual twin was found at the point of *d*

In all cases when the load was removed, any traces of the elastic twin disappeared entirely, provided it did not cut the side surface of the specimen.

We did not succeed to determine the optical properties of an elastic twin, since its thickness does not surpass one micron; we succeeded, however, in obtaining an elastic twin upon the side surface of the prism and, having recourse to great magnification, we became convinced, that the scratches on the side surface produce the same fault upon the elastic twin, as on the residual one (Fig. 1, *б* and *b*). Besides, after repeated loading and unloading which were followed exclusively by elastic twins, we have detected upon the polished surface of the crystal a trace, having the form of small separate flaws which one uses to observe in the case of repeated common twinning of calcite. In the next future we intend to give a detailed description of our experiments, as well as of the apparatus and instruments designed for the examination and measurements of the phenomenon, which we found appropriate to call «elastic twinning».

The Ukrainian Physico-Technical Institute.
Kharkov.

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GEOPHYSICS

ON THE DETERMINATION OF GRAVITY ANOMALIES FROM THE ASTRONOMICAL-GEODETICAL DEFLECTION OF THE PLUMB LINE

By N. MIHAL

(Communicated by S. I. Wawilow, Member of the Academy, 15.X.1938)

The main difficulties in the determinations of the figure of the geoid (1), as well as of the differences of the moments of the Earth's inertia (2), lie in the necessity of knowing the distribution of gravity anomalies for the whole surface of the Earth; and it is well known that the measurement of such anomalies for most of the regions of the globe involves considerable complications. Accordingly, indirect methods to be applied in the regions just mentioned deserve special attention. The present paper is devoted to one of such methods.

Denoting the distance from the level ellipsoid to the geoid by N, we have

$$N = H + L, \tag{1}$$

where H is the distance from the same ellipsoid to the reference-ellipsoid, L — the distance from the reference-ellipsoid to the geoid.

Taking a particular derivative along φ, where φ is the latitude of the point, we obtain:

$$\frac{1}{a_0}\frac{\partial N}{\partial \varphi} = \frac{1}{a_0}\frac{\partial H}{\partial \varphi} + \frac{1}{a_0}\frac{\partial L}{\partial \varphi}. \tag{2}$$

Here a_0 is the mean radius of Earth.

Let us now consider all the values in formula (2). $\frac{1}{a_0}\frac{\partial N}{\partial \varphi}$, the absolute deflection of the plumb line within the meridian plane, is determined according to Vening-Meinesz' formula (3):

$$\frac{1}{a_0}\frac{\partial N}{\partial \varphi} = \frac{1}{4\pi a_0^2 g_0}\int \Delta g \frac{Q(\psi)}{\sin\psi}\cos\alpha \, d\sigma. \tag{3}$$

In (3) the following notations are adopted: g_0 — mean acceleration of the Earth's gravity; $d\sigma$ — element of the surface of sphere S of radius a_0; Δg — H. Faye's anomaly referred to element $d\sigma$;

$$Q(\psi) = \cos^2\frac{\psi}{2}\left\{\operatorname{cosec}\frac{\psi}{2} + 12\sin\frac{\psi}{2} - 32\sin^2\frac{\psi}{2} + \frac{3}{1-\sin\frac{\psi}{2}} - \right.$$
$$\left. - 12\sin^2\frac{\psi}{2}\ln\left(\sin\frac{\psi}{2} + \sin^2\frac{\psi}{2}\right)\right\};$$

ψ — spheric distance from point A with latitude φ, in which the deflection of the plumb line is determined up to surface element $d\sigma$; α — azimuth of direction from this point to element $d\sigma$.

For the determination of $\frac{1}{a_0}\frac{\partial H}{\partial \varphi}$ we have resort to Prof. F. N. Krasovsky's (4) formula (it is here put down in a somewhat modified and simplified form):

$$H = \left\{\sin\varphi\sin\varphi' + \cos\varphi\cos\varphi'\cos\omega - 1\right\}\Delta a + a_0\sin^2\varphi'\left\{\sin\varphi\sin\varphi' + \right.$$
$$\left. + \cos\varphi\cos\varphi'\cos\omega - \frac{\sin\varphi}{\sin\varphi'}\left(2 - \frac{\sin\varphi}{\sin\varphi'}\right)\right\}\Delta\mu - M'\left\{\sin\varphi'\cos\varphi\cos\omega - \right.$$
$$\left. - \sin\varphi\cos\varphi'\right\}\delta\varphi' + R'\cos\varphi\cos\varphi'\sin\omega\delta\lambda' - \left\{\sin\varphi\sin\varphi' + \cos\varphi\cos\varphi'\cos\omega\right\}N'$$

We obtain:

$$\frac{1}{a_0}\frac{\partial H}{\partial\varphi} = \left\{\cos\varphi\sin\varphi' - \sin\varphi\cos\varphi'\cos\omega\right\}\frac{\Delta a}{a_0} +$$
$$+ \sin^2\varphi'\left\{\cos\varphi\sin\varphi' - \sin\varphi\cos\varphi'\cos\omega - \frac{\cos\varphi}{\sin\varphi'}\left(2 - \frac{\sin\varphi}{\sin\varphi'}\right) + \frac{\sin 2\varphi}{2\sin^2\varphi'}\right\}\Delta\mu +$$
$$+ \left\{\sin\varphi\sin\varphi'\cos\omega + \cos\varphi\cos\varphi'\right\}\delta\varphi' - \sin\varphi\cos\varphi'\sin\omega\,\delta\lambda' -$$
$$- \left\{\cos\varphi\sin\varphi' - \sin\varphi\cos\varphi'\cos\omega\right\}\frac{N'}{a_0}. \qquad (4)$$

Here ω is the longitude of point A, counted from the meridian passing through point B, in which the reference-ellipsoid is oriented; φ' — the latitude of point B; Δa — the difference between the bigger semiaxes of the level ellipsoid and the reference-ellipsoid; $\Delta\mu$ — the difference in compression of the same ellipsoids; $\delta\varphi'$ and $\delta\lambda'$ — changes in latitude and longitude caused by the absolute deflection of the plumb line at point B; N' — distance between the level ellipsoid and the geoid at the same point.

As regards the last term entering formula (2) $\left(\frac{1}{a_0}\frac{\partial L}{\partial\varphi} = \varepsilon_m\right.$ — the astronomical-geodetical deflection of the plumb line within the plane of the meridian$\left.\right)$, it is determined from astronomical-geodetical measurements.

Substituting in formula (2) expressions (3) and (4) and taking into consideration that in accordance with Vening-Meinesz' formulae (3):

$$\delta\varphi' = \frac{1}{4\pi a_0^2 g_0}\int_S \Delta g\frac{Q(\psi')}{\sin\frac{\psi'}{2}}\cos\alpha'\,d\sigma; \quad \delta\lambda' = \frac{1}{4\pi a_0^2 g_0\cos\varphi'}\int_S \Delta g\frac{Q(\psi')}{\sin\frac{\psi'}{2}}\sin\alpha'\,d\sigma,$$

and in accordance with Stokes' formula (1):

$$N' = \frac{1}{4\pi a_0 g_0}\int_S \Delta g S(\psi')\,d\sigma,$$

we obtain:

$$\frac{1}{4\pi a_0^2 g_0}\int_S \Delta g\frac{Q(\psi)}{\sin\frac{\psi}{2}}\cos\alpha\,d\sigma = \left\{\cos\varphi\sin\varphi' - \sin\varphi\cos\varphi'\cos\omega\right\}\frac{\Delta a}{a_0} +$$
$$+ \sin^2\varphi'\left\{\cos\varphi\sin\varphi' - \sin\varphi\cos\varphi'\cos\omega - \frac{\cos\varphi}{\sin\varphi'}\left(2 - \frac{\sin\varphi}{\sin\varphi'}\right) + \frac{\sin 2\varphi}{2\sin^2\varphi'}\right\}\Delta\mu +$$
$$+ \frac{1}{4\pi a_0^2 g_0}\left\{\sin\varphi\sin\varphi'\cos\omega + \cos\varphi\cos\varphi'\right\}\int_S \Delta g\frac{Q(\psi')}{\sin\frac{\psi'}{2}}\cos\alpha'\,d\sigma -$$
$$- \frac{1}{4\pi a_0^2 g_0}\sin\varphi\sin\omega\int_S \Delta g\frac{Q(\psi')}{\sin\frac{\psi'}{2}}\sin\alpha'\,d\sigma -$$
$$- \frac{1}{4\pi a_0^2 g_0}\left\{\cos\varphi\sin\varphi' - \sin\varphi\cos\varphi'\cos\omega\right\}\int_S \Delta g S(\psi')\,d\sigma + \varepsilon_m, \qquad (5)$$

where

$$S(\psi') = \operatorname{cosec}\frac{\psi'}{2} + 1 - 6\sin\frac{\psi'}{2} - 5\cos\psi' - 3\cos\psi'\ln\left[\sin\frac{\psi'}{2} + \sin^2\frac{\psi'}{2}\right];$$

ψ' is the spherical distance from point B to element $d\sigma$. α' — the azimuth of direction from this point to surface element $d\sigma$.

Let us divide the whole surface of the Earth into a number of regions, n. Let the gravity forces be measured in a direct way in regions m; then the number of regions where the force of gravity is unknown will equal $n-m$. It is easily seen that formula (5) provides us with an equation with $n-m$ unknown anomalies of gravity representing $n-m$ regions. In fact, substituting sums for the integrals used in formula (5), we obtain an equation of the following appearance:

$$\sum_{i=m+1}^{i=n} E_i \Delta g_i + K = 0, \tag{6}$$

where

$$E_i = \frac{1}{4\pi a_0^2 g_0} \left\{ \frac{Q(\psi_i)}{\sin \frac{\psi}{2}} \cos \alpha_i - [\sin \varphi \sin \varphi' \cos \omega + \cos \varphi \cos \varphi'] \frac{Q(\psi_i')}{\sin \frac{\psi_i'}{2}} \cos \alpha_i' + \right.$$
$$\left. - \sin \varphi \sin \omega \frac{Q(\psi_i')}{\sin \frac{\psi_i'}{2}} \sin \alpha_i' - [\cos \varphi \sin \varphi' - \sin \varphi \cos \varphi' \cos \omega] S(\psi_i') \right\} \Delta\sigma_i;$$

$$K = \sum_{i=1}^{i=m} E_i \Delta g_i - \left\{ \cos \varphi \sin \varphi' - \sin \varphi \cos \varphi' \cos \omega \right\} \frac{\Delta a}{a_m} - \sin^2 \varphi' \left\{ \cos \varphi \sin \varphi' - \right.$$
$$\left. - \sin \varphi \cos \varphi' \cos \omega - \frac{\cos \varphi}{\sin \varphi'} \left(2 - \frac{\sin \varphi}{\sin \varphi'} \right) + \frac{\sin 2\varphi}{2 \sin^2 \varphi'} \right\} \Delta\mu - \varepsilon_m.$$

In deducing equation (6) we differentiated (1) along φ; differentiating it along ω, we obtain one equation more;

$$\sum_{i=m+1}^{i=n} E_i' \Delta g_i + K' = 0, \tag{7}$$

where

$$E_i' = \frac{1}{4\pi a_0^2 g_0} \left\{ \frac{Q(\psi_i)}{\sin \psi_i} \sin \alpha_i - \sin \varphi' \sin \omega \frac{Q_1(\psi_i')}{\sin \frac{\psi_i'}{2}} \cos \alpha_i' - \right.$$
$$\left. - \cos \omega \frac{Q(\psi_i')}{\sin \frac{\psi_i'}{2}} \sin \alpha_i' - \cos \varphi' \sin \omega S(\psi_i') \right\} \Delta\sigma_i;$$

$$K' = \sum_{i=1}^{i=m} E_i' \Delta g_i - \cos \varphi' \sin \omega \frac{\Delta a}{a_0} - \sin^2 \varphi' \cos \varphi' \sin \omega \Delta\mu - \cos \varphi \delta\omega;$$

$\delta\omega$ is a correction for longitude ω, necessitated by the astronomical-geodetical deflection of the plumb line.

Having determined the astronomical-geodetical deflection of the plumb line in $\frac{n-m}{2}$ points and having constructed according to the aforesaid method a system of linear equations with $n-m$ unknowns, we, upon solving this equation, obtain the anomalies of gravity referring to $n-m$ regions.

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CHEMISTRY

A METHOD OF PRODUCING PURE COMMON SALT THROUGH BIHYDRATE OF SODIUM CHLORIDE $NaCl.2H_2O$

By V. I. NIKOLAEV and B. I. STEPANOV

(Communicated by N. S. Kurnakov, Member of the Academy, 3. X. 1938)

The cold weather of winter and the high temperatures of summer should be made use of in the industrial life of our Union.

Along with the well-mastered commercial method to produce common salt from sea-water in reservoirs through evaporation in the sun during the summer season, pure common salt can be obtained also after the same reservoir method from impure, low-quality salt in places where it occurs, provided, of course, that there is fresh water or sea-water of insignificant salt concentration in the neighbourhood, or that it is possible in general to make use of the same. It is also necessary that there be low enough winter temperatures, down to —5°, —8°.

Such conditions exist, for instance, in the radical salt lakes, situated in the delta of the river Volga (in the Astrakhan region, Kalmuckia), or in Lake Kuuly, Karabugaz region, and other places.

In this short publication we should like to attract the attention of all organizations interested to a method of purifying inferior grades of common salt in general through the bihydrate of sodium chloride $NaCl.2H_2O$ which forms at temperature of 0° and lower.

We shall describe some experiments conducted at the Kalmuck salt station with the purpose of obtaining very pure salt from impure common salt. For the experiments we took common salt from Great Basinsky Lake. Its composition was as follows (according to analysis)(in %):

$Ca(HCO_3)_2$	= 0.20
$CaSO_4$	= 0.88
$MgSO_4$	= 0.16
$MgCl_2$	= 0.35
NaCl	= 96.43
Undissolved residue (silt) and water	= 1.98
Total	=100.00

1) 461.8 g water were added to 500 g of this salt in pulverized form. This is one and a half times the amount of water by weight required theoretically for the formation of the bihydrate NaCl. 2aq.

After stirring, the mixture thus produced was cooled to —7°, —8°. The turbid mother-water was poured off from the crystals of the hydrate NaCl.2aq

which formed above 0° the pure crystalline bihydrate residue separated into a saturated solution and crystals of NaCl. About 250 g of the latter, i. e. 50% of the initial quantity, was gathered and pressed dry.

The quality of the common salt thus obtained can be seen from the following analysis (in %):

$Ca(HCO_3)_2$	= 0.06
$CaSO_4$	= 0.34
$MgSO_4$	= 0.09
$MgCl_2$	= 0
NaCl	= 97.7
Water	= 1.81
Total	=100.00

The NaCl content calculated for the dry salt is 99.4%. Magnesium chloride turned out to be entirely washed out of the initial salt, the quantity of gypsum and calcium carbonate decreased three times and the $MgSO_4$ content was twice less. Apparently if the mother-brine were removed more completely, for instance by centrifuging, we could have obtained a salt with a greater content of NaCl than 99.4%.

2) The turbid mother-water was poured off with the filtrate. The experiment was repeated with 530 g of this brine.

Since this brine contained 26.08% NaCl (138.7 g NaCl and 392 g water), we added 456.3 g of impure salt to the brine, according to the former calculations. After freezing to —7°, —8° and pouring the mother-water from the sodium chloride bihydrate crystals, the latter yielded 417 g after fusion, i. e. 65% of the initial quantity of common salt, which showed the following composition after being pressed and slightly dried (in %):

$CaSO_4$	= 0.50
$MgSO_4$	= 0.10
NaCl	= 98.92
Water	= 0.28
Undissolved residue	= [illegible]
Total	=100.00

The NaCl content in the dry salt is 99.2%.

The common salt thus obtained from this repeated procedure was slightly worse than before, but still of high enough quality.

The residual mother-water which is saturated with common salt can be just poured back into the lake for instance: as the water evaporates in the sun, the common salt will precipitate and be treated again. Each purification of inferior quality salt may be expected to yield 50 to 60% of the initial quantity in pure salt. In these operations the reservoirs can evidently be deep enough, so far as commercial premise will permit. They only have to be furnished with devices for removing the impure mother-water, which forms on the surfaces of the sodium chloride bihydrate crystals.

Even if there is no possibility of using artificial cold, these operations may be repeated during the cold months of the year.

[illegible]
Academy of Sciences of the USSR.

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CHEMISTRY

ADSORPTIVE PROPERTIES OF CLAY (KAOLIN)

By V. I. NIKOLAEV and E. I. RUDENKO

(Communicated by N. S. Kurnakov, Member of the Academy, 4. X. 1938)

With this paper we proceed in reporting our results obtained from studying the absorptive properties of the separate components of the complicated silt complex.

We have already shown(1) that colloidal iron oxide is present in silts in the form of a product which has adsorbed all the cations and anions of natural first class brine with the exception of $Ca^{\cdot\cdot}$ and $Mg^{\cdot\cdot}$, and which is coated with a thin iron sulphide (or hydrosulphide) shell only on the surface of the colloidal grain.

Another of the components of the silt complex is clay. For our study of the adsorptive properties we succeeded in obtaining a kaolin sample of great purity, containing 99.59% pure clay which is evident from the following analysis made by us (in %):

SiO_2	= 46.423 → 0.773	moles
Al_2O_3	= 39.296 → 0.387	»
H_2O	= 13.871 → 0.771	»
Fe_2O_3	= 0.103	
FeO	= 0.093	
$CaCO_3$	= 0.050	
$CaSO_4$	= 0.015	
CaO	= 0.150	
KCl	= 0.023	
Total	= 100.024	

→ 99.59% $2H_2O Al_2O_3 2SiO_2$

After removing slight admixture of soluble salts from the clay by washing a number of times with hot water, 10 g of clay, dried at about 100° and finely ground, was shaken for 3 hours with 100 g of a synthetic solution of definite composition, and then the composition of the solution after shaking was compared with the composition before shaking.

a) Ions in the solution before shaking, %		b) Ions in the solution after shaking, %	
Cl'	= 14.893	Cl'	= 14.943
SO''_4	= 0.448	SO''_4	= 0.448
Br'	= 0.067	Br'	= 0.067
$Ca^{\cdot\cdot}$	= 0.033	$Ca^{\cdot\cdot}$	= 0.034
$Mg^{\cdot\cdot}$	= 0.232	$Mg^{\cdot\cdot}$	= 0.232
$Na^{\cdot}$	= 9.364 (calculated)	$Na^{\cdot}$	= 9.334 (calculated)
$K^{\cdot}$	= 0.089	$K^{\cdot}$	= 0.080
Total	= 25.126	Total	= 25.028
Dry residue	= 25.140	Dry residue	= 25.030

The decrease of dry residue in the solution after shaking with clay is already enough to show that brine ions are adsorbed by the clay.

Recalculating the absorption values of separate ions for 100 g clay we get:

Quantity of ions adsorbed in g	in g-equivalents
$Na^{\cdot}$ = 0.300 →	0.0130
$K^{\cdot}$ = [illegible] →	[illegible]
Cl' = 0.500 →	0.0140
Br' = [illegible] →	[illegible]
SO''_4 = 0	—
$Mg^{\cdot\cdot}$ = 0	—
$Ca^{\cdot\cdot}$ = 0	—

We see that the sum of the gram-equivalents of the adsorbed cation ($K^{\cdot}+Na^{\cdot}$) = [illegible] and is exactly the same as the sum of adsorbed anions ($Cl'+Br'$) = [illegible], i. e. we have observed a molecular adsorption of sodium and potassium chlorides and bromides, probably in the form of NaCl(Br) and KCl(Br)[illegible], just as in the case of colloidal iron oxide [illegible]; we did not observe any adsorption of $Ca^{\cdot\cdot}$ nor $Mg^{\cdot\cdot}$ ions, consequently these ions are adsorbed by some other components of the silt complex. Clay does not adsorb the SO''_4 ions either; the latter is adsorbed, as we have noted before, by colloidal substituted iron oxide[illegible].

In order to qualitatively and quantitatively compare the values of adsorption of separate ions by clay and by the entire mud complex, we washed some mud (from Lake [illegible]) with water until it gave no Cl' ion reaction, and then elutriated a weighed portion of 100 g in the cylinder of Sabanin's apparatus and collected the particles whose dimensions were not over 0.01 mm.

After being dried at [illegible]° and ground to powder the greyish-green mixture was analyzed with the following results (in %):

SiO_2 =	[illegible]	K_2O =	[illegible]
Al_2O_3 =	[illegible]	Na_2O =	[illegible]
MgO =	[illegible]	Fe_2O_3 =	[illegible]
CaO =	[illegible]	FeO =	[illegible]
The loss when drying and calcining was			[illegible]
		Total =	[illegible]

From the Al_2O_3 content in the elutriated fraction, equal to [illegible]%, we may conclude that the mixture obtained did not contain more than [illegible]% pure clay. Shaking 100 g of the substance with 50 g of the clay fraction gave us a solution of the following composition (in %):

Cl' = 11.840	$Mg^{\cdot\cdot}$ = 0.230
SO''_4 = 0.448	$K^{\cdot}$ = 0.077
Br' = 0.052	$Na^{\cdot}$ = 9.329
$Ca^{\cdot\cdot}$ = [illegible]	

Calculating for 100 g of this clay fraction, the quantities of ions adsorbed from the brine are as follows (in g):

Cl' = 0.53	$Mg^{\cdot\cdot}$ = 0.02
Br' = 0.15	$Ca^{\cdot\cdot}$ = 0
$K^{\cdot}$ = 0.12	SO''_4 = 0 *
$Na^{\cdot}$ = 0.35	

* The reason why we did not observe any adsorption of the SO''_4 by the mud complex is that it is impossible to wash this ion out of the mud with water preliminarily, and it [illegible] always be present, even after the mud has been washed for [illegible].

Just as should have been expected, the adsorption values of the separate brine ions by the mud complex are somewhat greater than the adsorption values of the same ions by pure clay. Calculations show that the clay of the mud adsorbs (in %):

94.3 of the Cl' ion	75.0 of the $K^{\cdot}$ ion
66.6 » » Br' »	85.7 » » $Na^{\cdot}$ »

the other components of the mud complex adsorb the rest of these ions.

A newly found(2) pronounced adsorption of the Cl' ion by both pure clay and the mud complex is a matter of special interest.

In some of our experiments we also observed the adsorption by clay and mud of the Cl' ion from NaCl solutions of various concentrations.

From all that has been said we may conclude that the constancy of chlorine ion concentration cannot possibly serve as a basis to estimate the age of natural water basins [Caspian Sea (3), Karabugaz Bay(4) etc.].

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CHEMIE

ÜBER DIE ZAHL DER PHYSIKALISCH EINFACHEN KRISTALLFORMEN

Von G. B. BOKY

(Vorgelegt von N. S. Kurnakov, Mitglied der Akademie, d. 15.IX.1938)

Die Zahl der einfachen Kristallformen ist 47. Jedoch behaupten einige Autoren, sie sei grösser. A. N. Boldyrev hat dieser Frage einen Aufsatz(1) gewidmet, in dem es ihm gelungen ist, die Existenz von 48 oder mehr einfachen Formen zu widerlegen.

Untersuchen wir die begangenen Fehler, so stellt es sich heraus das ein und dasselbe Polyeder, in verschiedenen Symmetrieformen vorgekommen, für verschiedene einfache Formen gehalten wurde. Indessen sind sie nur als Varietäten derselben einfachen Form zu betrachten.

Was soll nun dem Begriff Varietät entsprechen? Die Frage ist nicht neu und zwar hat A. V. Schubnikov im Jahre 1925(2) einen analogen Fall beschrieben, nämlich 5 physikalisch verschiedene Würfel. Der Verfasser entwickelt den Gedanken die physikalisch abweichenden Formen «seien als verschiedene Formen aufzufassen».

Wir stellten uns zur Aufgabe alle mögliche physikalisch verschiedene einfache Kristallformen abzuleiten.

Zwei gleiche einfache Kristallformen sind physikalisch verschieden, sobald sie sich voneinander durch ihre Symmetrie unterscheiden.

Somit wollen wir drei tetragonale Prismen als physikalisch verschieden betrachten, wenn die Begrenzungsflächen der einen die Symmetrie $L_2 2P$ besitzen, während in dem zweiten diese Symmetrie beispielsweise nur L_2 ist, und die Begrenzungsflächen der dritten gar keine symmetrischen Elemente haben (die tetragonal-pyramidale Symmetrieklasse liefert nur ein Beispiel hierzu).

Es liegt nahe, dass die Zahl der tetragonalen Prismen, welche keine ihren Begrenzungsflächen perpendikulären Symmetrieelemente besitzen, unendlich gross ist, und dennoch müssen wir von dem Standpunkt der Symmetrie aus diese Prismen zu einem Typus rechnen, ebenso wie wir die unendliche Zahl der rhombischen Prismen, tetragonalen Pyramiden u. s. w. als eine Form betrachten, wenn wir alle Kristallformen auf die 47 einfachen zurückführen.

Der Unterschied nach der Symmetrie trägt einen qualitativen Charakter. Was aber die quantitativen Abweichungen betrifft, so kann jede Eigenschaft deren unendliche Zahl aufweisen. Unter der Symmetrie einer einfa-

chen Form darf man nicht allein die Gesamtheit der den Begrenzungsflächen perpendikulären Symmetrieelemente verstehen, obwohl ihr Vorhandensein am deutlichsten hervortritt. Wir müssen auch alle diejenigen Symmetrieelemente mitberechnen, welche den Begrenzungsflächen der einfachen Form parallel laufen oder sie unter schrägen Winkeln schneiden. Zur Ableitung sämtlicher physikalisch verschiedener einfacher Kristallformen muss man zuerst in jeder Symmetrieart alle allgemeinen und privaten einfachen Formen erhalten und dann aus der sich daraus ergebenen unendlichen Reihe alle die quantitativ identischen ausschalten.

Diese Arbeit wurde von uns durchgeführt. Es erwies sich, dass die Zahl der physikalisch verschiedenen einfachen Kristallformen mit 146 zu schätzen ist, unter der Bedingung dass man die gleichen enantiomorphen Formen als identische behandelt. Der Begriff «gleiche enantiomorphe Formen» bezieht sich auf solche Vielflächer, von denen einer das Spiegelbild des anderen darstellt. Als bestes Beispiel aus der Kristallographie könnten hier die Trapezoeder gelten.

Wenden wir uns beispielsweise zu der tetragonal-trapezoedrischen Symmetrieart, in der das tetragonale Trapezoeder eine allgemeine Form repräsentiert, so sehen wir, dass hier noch 4 private einfache Formen vorkommen können: Pinakoid, tetragonales Prisma, tetragonale Dipyramide und ditetragonales Prisma.

Eine nach dieser Symmetrieart kristallisierende Substanz kann solche Kristalle bilden, deren Begrenzungsflächen keine allgemeine Form (Trapezoeder) aufweisen. Eventuel können sie eine Vereinigung des tetragonalen Prismas mit Pinakoid darstellen. Dadurch verlieren sie selbstverständlich als Spiegelisomere ihre physikalische Verschiedenheit nicht und bleiben physikalisch verschieden trotz der Identität ihrer äusseren Form. Wir bezeichneten solche einfachen Formen (gegebenenfalls tetragonale Prismen und Pinakoide) als «physikalisch enantiomorphe». Es erwies sich nach der Berechnung, dass man in der Kristallographie 47 physikalisch enantiomorphen einfachen Formen begegnet.

Die Arbeit, welche ausführliche Berechnungen, Tabellen und das Verzeichnis aller physikalisch verschiedenen einfachen Formen enthält, wird demnächst erscheinen.

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GEOCHEMISTRY

TO THE GEOCHEMISTRY OF THE ENVIRONS OF KISLOVODSK

By A. E. FERSMAN, Member of the Academy

1. The numerous investigators of the Kislovodsk health-resort have not suspected up to the present time that in the nearest neighbourhood of Kislovodsk itself there may be found a number of very interesting mineral formations, not only yielding new data on the mineralogy of the Lower Cretaceous deposits of North Caucasus, but also throwing light on some geochemical problems connected with the still obscure question of deep-seated water mineralization(1).

The large construction work undertaken at Kislovodsk necessitates the production of several tens of thousands cubic meters of dressed stone, mainly, chiefly massive yellow and grey dolomitized limestones from the Lower Valanginian horizons (containing up to 15% MgO). These horizons are exposed by a system of quarries, especially following the course of the Alikonovka river between the «Medovy» Waterfalls and the «Kovarstvo i Liubov» castle.

Building dolomites and dolomitized limestones are underlain here by Titonian series, an alternation of red and bright green clays (evidently due to a combination of Fe^{+3}—Fe^{+2}) with siliceous sands and granitic gravel, occasionally with gypsum, lying directly on granite gneisses, probably of Caledonian age.

From the geochemical viewpoint the section is as follows:

a) Cavernous limestones, partly conchoidal and partly ..., subject to surface infiltration.

b) Massive limestones and dolomites of the Valanginian, up to 50—70 m in thickness, cleaved into large blocks.

c) Argillaceous bands and granite gravel, up to 10 m in thickness.

d) Red granite and granite gneisses.

Thus, the Valanginian rocks are geochemically dependent upon three processes:

1) primary accumulation and partial transference of substances within themselves;

2) infiltration of thermal solutions from above;

3) uprush of mineralized solutions from the granitic gravel below.

2. The minerals described below are encountered in numerous geodes and cavities of the Valanginian. It is interesting to note that the geodes are commonly of a closed nature, not interconnected by visible fissures, though frequently drawn out and extending horizontally; they reach 20—40 cm in size, and being mostly enveloped in silica materials, they reach the sur-

formity of building stones, this being regarded as a defect from the technical viewpoint. When hit they sometimes fall out of the limestone and dolomite in the form of ball concretions. In their center hollows are usually discovered, lined with flowers of blue celestine and small crystals of white and yellow calcite. Less frequently the geodes are completely filled with calcite and silicic sediments with «brushes» of rock crystal. The latter is predominant in Berezovaya Balka and in the quarries near the «Kovarstvo Listvy» castle, while geodes rich in celestine are encountered especially within the area lying about half-way along the Alikonovka river course between the castle and the Medovy Waterfalls. It is noteworthy that neither of the minerals described below is encountered in the dolomite fissures except the gypsum, filling these fissures as continuous sheets.

The following minerals have been encountered:

1) Quartz—lines the hollows of geodes and partly forms small crystals with a short prism and without striation, partly enveloped and ended by white chert.

2) Chalcedony—appears only as a secondary product in the course of recrystallization of primary silicic hydrate.

3) Flint-agate—large stalactitic, less frequently zonary laminated masses, filling the geodes up to a child's head in size. Typically colloidal formations. The water content in the massive white substance is only about 1%. Under the microscope a peculiar structure is observed.

4) Goethite and limenite—negligible films and patches on semi-opal, frequently as a centre of crystallization of calcite rhombohedra.

5) Calcite—in some cases fills the geodes, especially in the upper portions of the dolomite series, occasionally forming there large crystals of perfectly developed scalenohedra $(21\bar{3}1)$ up to 5 cm along the vertical axis. In other cases calcite forms irregular isometric crystals of complex combinations in silicic geodes.

6) Pyrite—cubes in the very rock, occasionally as fillings of small cavities together with calcite.

7) Sphalerite—a dark variety of marmatite, in massive crystalline accumulations up to several cubic centimeters in size, sometimes associated with pyrite; when oxidized the formation of sulphate and carbonate crusts of a bright-yellow colour (presence of cadmium) is noticeable.

8) Gypsum—belongs to later generations, chiefly in fissures, less frequently fibrous or in the form of transparent lamellae in the geode hollows.

9) Baryte—very rare, in the form of small feathery brushes of a milky colour [2].

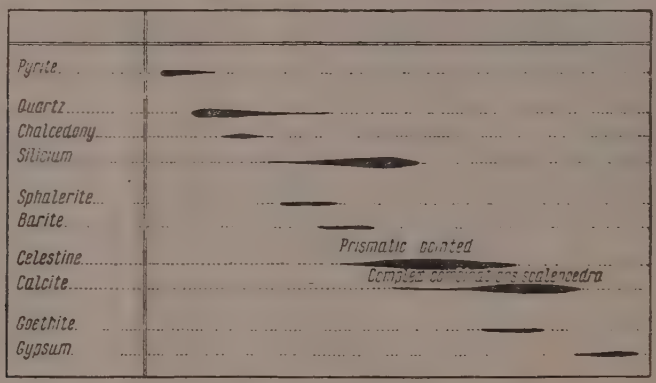
10) Celestite—the most interesting mineral in perfectly developed small crystals with many faces of a beautiful blue colour, up to 2 cm in size. Those of an earlier generation show irregular barrel-shaped forms, later generations are pointed, with many faces, drawn out along the axis X. It is interesting to note that the most intensive colouring appears at the middle of the crystallization process, changing to a slightly bluish one towards its close. Under treatment with surface carbonic waters the crystals become eroded and of a lighter colour. A peculiar lightening of the colour, which is very deep directly after the breaking-up of the geodes and gradually loses its intensity under the influence of the sun. From the abundance of the crystallographic material, the purity and variety of faces and their habit, the deposit belongs to the most interesting of the crystalline celestite formations known in the Union, and requires a detailed mineralogical and geochemical study [3,4].

3. Geochemical Characteristics. From the aforesaid the following ions may be established in the geode formations of the Valanginian of Kislovodsk:

cations: Mg^{+2}, Ca^{+2}, Sr^{+2}, Ba^{+2}, Zn^{+2}, (Cd^{+2}), H^{+1}
anions: S^{-2}, $[SO_4]^{-2}$, $[CO_3]^{-2}$, $[OH]^{-1}$, $[SiO_4]^{-4}$

Curiously enough, cinnabar (Hg^{+2}) has been found by the geologists of the local Geological Trust in the sands of Alikonovka.

The above list is characterized by the predominance of ions of ± 2 valence with values of lattice energy (Eck) below unit (for cations) which expresses fairly well the energetics of the process—the absence both of multivalent and energetically powerful ions and of monovalent ions, forming compounds of high solubility and very low lattice energy values. It should be noted that judging



by the paragenesis, in individual horizons underlying the Tithonian certain segregations of granite decomposition products, viz. gold and cassiterite might be expected, which minerals require a special investigation of individual horizons. The accompanying table shows the sequence of crystallization of individual minerals of the deposits; curiously enough, the sequence tends to an increase of solubility and a drop of hardness.

General Conclusions

The above mineralogical observations are interesting with regard to the composition and genesis of the Kislovodsk mineral waters. It should be kept in mind that a number of the components of the Chief Narzan and the dolomite Narzan are connected with the granite gravel underlying the Valanginian rocks. The Narzan consists chiefly of juvenile CO_2 and of products of element extraction from the granite gravel or the dolomite limestones of the Lower Cretaceous it practically springs from.

Thus, the following elements are typically granitic: Sr, Ba, Zn, Mn, P, Li, F, B, Ra, Pb, and some others. These very components determine the typical features of the Narzan mineral waters. It is possible that these waters, circulating in the Cretaceous horizons of the Valanginian too, result in the enrichment of the latter in these mineral formations.

It may also be assumed that these formations fail to be genetically connected with the Narzan itself, but (which is even more probable) have like the latter as primary source the granite gravel, covering the Caledonian granites and granite-gneisses, underlying the Lower Cretaceous.

At any rate, the finding in the horizons of the Valanginian of a number of peculiar minerals touches upon some questions of great geochemical importance for the whole region, and necessitates a thorough and detailed study of individual horizons of the Cretaceous, in order to establish a more definite genetic connexion of the minerals both with the underlying products of granite disintegration and the mineral waters of the Kislovodsk health-resort. A general study of the geochemistry of Sr in the Lower Cretaceous and Upper Jurassic deposits of the North Caucasus ([5]), which is evidently of a general regional and paleogeographical importance, would be of interest ([6]).

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BIOCHEMISTRY

A NEW VALUABLE BEARER OF VITAMINE AND ITS COMMERCIAL USE

By A. K. GERGELEGIU

(Communicated by A. N. Bach, Member of the Academy, 13. VII. 1938)

While appraizing the wealth of anti-scorbutic raw materials within the territory of Moldavian Autonomous Soviet Social Republic, we occasionally met with the fact that unripe walnut (*Juglans regia* L.) conceals an exceedingly high content of anti-scorbutic vitamine. This was unexpected because the nuts along with cereals and leguminous were believed not to contain vitamine C at all([5]). We, however, obtained more than one per cent vitamine to raw weight of green walnut. On account of the independent interest this finding presents, we deemed it wise to publish the data obtained in a separate communication.

The work was being done in 1936—37. Vitamine C was estimated by indophenol titration after the method of Bukin([3]). The chief objects were, moreover, subjected to biological tests on guinea-pigs. Thereby we invariably observed a close consistency between the chemical and the biological data.

Content of Vitamine C in Green Walnuts. The green walnuts taken for analysis were unripe in different degree. The results obtained are summarized in Table 1.

It may be seen from this table that the fruit is storing vitamine C during the first 20 days of its development. The store is stopped with the first signs of husk's hardening and the content of vitamine C goes down as ripening goes farther. With regard to the content of vitamine C the unripe walnuts display a seven times higher activity compared to the best varieties of black-currant, being 40—50 times more active than the oranges and lemons. They rank among the richest sources of vitamine C such as eglantine fruit([1,2]) and actinidia berries([6]). It is of importance too that the cultivation of walnuts presents a steady commercial basis already at our disposal. Green walnuts' wealth of Moldavia alone amounts to 1800—2400 tons. Taking into account a number of other regions in this country as Crimea, North Caucasus, Transcaucasia, Middle Asia, etc., it will be obvious that we are possessing very great capabilities to develop the respective industry.

Green walnut has long been used in confectionary as preserved fruit and we have only to endeavour a judicious and extensive development of the industry already available. As our investigation of the latter showed that with the technique now applied the vitamine C is entirely lost, we paid special attention to the question of adequate treatment of green walnut.

Stability of Vitamine C in Walnut and Some Methods of Using the Latter. The waste of vitamine C in walnut treated after usual procedure might be put down, among other fac-

Table 1

Content of Vitamine C in Walnut, Depending on Stage of Development (mg% of raw weight)

Date of analysis	Characteristics of nuts	Weight of 1 nut in g	Weight of skin in g	Weight of core in g	Vitamine content in mg per 100 g	
					in core	in skin
1937						
25.V	Earliest stage; the kernel (seed) is scarcely distinguishable from the husk (endocarp), the walnut is bitter, unsuitable to treatment .	4.0	—	—	1 667	—
5.VI	The forming kernel can be distinguished within the fruit which is still bitter, unsuitable to treatment	14.0	8.6	5.4	2 281	1 949
11.VI	The kernel is easy to separate from the husk, jelly-like, slightly bitter, the walnut is quite ready to treatment	29.0	15.0	14.0	2 573	2 245
14.VI	Do	32.2	16.4	15.8	3 036	2 549
17.VI	Do	33.2	17.8	16.0	2 789	2 456
19.VI	Do	34.0	18.0	16.0	2 346	2 006
23.VI	The husk grows hard in its upper part, the jelly-like consistence of the kernel is thickening	35.5	20.1	15.4	1 873	1 658
29.VI	Do	36.2	20.1	16.1	1 349	1 467
2.VII	The husk is hard all over its surface, difficult to cut with knife, the walnut is not quite suitable to treatment	39.0	18.5	20.5	1 063	1 419
5.VII	Do	39.0	18.0	21.0	749	1 200
11.VII	Husk very hard, walnut quite unsuitable to treatment	40.0	—	—	487	1 164
22.VII	Do	41.0	—	—	238	1 12
11.VIII	The kernel is growing ripe, the husk has strongly hardened and taken a dark-brown colour	43.0	—	4.0	85	831

tors, to the action of ferments which oxidize the ascorbic acid into its very unstable dehydro-form(4). Our investigation, however, of the activity of ascorbinase showed the very low content of this ferment: there were oxidized 1. 28—3.5 mg of ascorbic acid per hour per 1 g of tissue, i. e. complete oxidation would engage 3—5 hours at least. In this respect too we thus find the green walnut to possess good technological properties. The chief reason of walnut loosing its vitamine proved to lie in the latter being washed out during blanching and subsequent washing. By changing the procedure of treatment (turning the blanching water to account and removing the washing) we were successful to produce different kinds of preserved fruit which were not behind of the trade samples as regards taste and appearance, having retained, at the same time, from 81.5 to 94% of the initial amount of vitamine. Some of the analyses of the samples obtained are referred to in Table 2.

Yet, with making preserves there remains still room for some waste of vitamine, and we were therefore endeavouring to find out more reliable ways for turning the walnut to account. Such was found in concoction of usual sweetened fruit juices. The tissue of the walnuts chopped in a meat-

mincer was blanded with sugar either immediately or after short boiling and bottling. or else the juice was preliminarily pressed out of it and, without being allowed to stand a long time, mixed with boiling sugar solution. All these procedures gave complete preservation of vitamine C with no loss whatever during 280 days. These experiments are sure to substantiate the high value we have set above on the technological qualities of the walnut as vitamine bearing raw material. It should thereby be mentioned that the syrups made had excellent flavour reminding of liqueur, and one could expect them to enjoy a wide, practically unlimited consumption. They must, therefore, be introduced into our food industry. We completed the series of our experiments with the attempt to get concentrates of the green walnut juice by means of simple evaporation. The preparation thus obtained proved very active and could also find extensive use both per se and for vitaminization of number of articles. In Table 2 we are referring to some results drawn from those experiments.

Table 2

Conservation of Vitamine C with Reference to Treatment of Green Walnut

Method of treatment	Content of vitamine C in mg%			Conservation of vitamine in %
	in raw material	in mixture before treatment	in finished articles	
Preserve from peeled sulphitized nuts	1 143	439	347	81.5
Do	849	297	278	94.0
Preserve from unpeeled sulphitized nuts	849	509	478	92.7
Preserve from peeled nuts treated with citric acid (2%) instead of sulphitization	1 667	847	765	90.0
Sweetened juice from unpeeled nuts (sugar, 68%)	997	319	319	100
Do, from skin (sugar, 60%)	1 870	748	748	100
Do, from peeled nuts (sugar, 50%)	1 870	935	935	100
Concentrate from the juice of sulphitized nuts, evaporated to 18.8%	997	—	4 890	92.2
Do, evaporated to 18%	997	—	5 177	96.9
Do, evaporated to 19.7%	1 345	—	6 128	89.5

The results obtained point undoubtedly to the green walnut being a new kind among most valuable vitamine bearing raw materials. Possessing high technological qualities it can be readily turned by adequate treatment into vitamine articles and must therefore be recommended for extensive use to our food industry. Alongside of this the data obtained prompt us to test other nuts, as chestnut, almond, pistachia-nut, etc., in which unripe fruit we can expect to find large stores of vitamine C. This work is now in progress and the chestnut, for instance, has already proved to contain such amounts of vitamine C, as approach to those revealed in the walnut.

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GEOLOGY

TO THE CHARACTERISTICS OF THE BRECCIA-LIKE AND BANDED LAVAS OF THE VOLCANO ELBROUZ

By D. S. BELIANKIN, Corresponding Member of the Academy

Breccia-like and banded structure has been known to be inherent to a greater or lesser extent to a number of volcanoes, so that the lavas of the Elbrouz are no exception in this respect. Indications as to a certain heterogeneity in the structure of these lavas are to be found in Kupffer's[7] report of the expedition of the Academy in the Elbrouz region, dating as far back as 1829. While describing the «trachytic» rock from samples broken by himself from a cliff in the firn region of the volcano, he states that this rock has in general the aspect of a porphyre-obsidian (terminology of the time), but that it is at the same time broken in different directions by fissures, and from these fissures it had derived its red colour, which is probably due to the oxidation of ferrous oxide filling these fissures.

The first detailed petrographical description of the spotted banded structure of the Elbrouz-lava was given in 1900 by Dannenberg [5], the material having been collected by the author himself at the northern slopes of Elbrouz, in the upper part of the Malka river valley, in 1897. Along with the more common black and light-grey varieties of lavas, their schlieren-banded types presented the same hypersthene (hypersthene-amphibol) dacites, with alternating black and red areas, the red ones including less plagioclase phenocrysts; on the other hand, small scales of biotite of a light-bronze or almost golden colour have been observed. The relation of the red and black areas is represented by Dannenberg in the following way: «In some cases the black areas have an irregular angular shape, with clearly pronounced boundary-lines, though lacking any marked elongation in a definite direction; they are rather of the nature of quite foreign bodies, captured by reddish lava, that still failed to alter them. In other cases a certain elongation of the black areas occurs, while the boundaries between them and the red areas remain as sharp as hitherto. Finally, there occur some pieces which display a still closer interlacing of black and red areas; occasionally having the form of parallel interlacings. The thickness of these varies from 1 cm to 1 or several mm. In most cases black areas, thinning out, wedge into red ones as narrow, dark reddish-brown strips. Since, besides the above three ways of distribution, there exists a whole range of intermediate conditions, we have hardly any reason to doubt that the schlieren and banded-laminated structure observed here is due to fractures of older black lava being captured by the red one, rather than to mere

differentiation. Later on such pieces acquired some plasticity and, carried away by the general flow of the lava, stretched more or less, forming towards the close of the process eutaxitic lavas» (5).

According to Dannenberg, microscopic examination of the black and red areas of the lava shows them to be almost identical: the ground mass varies from vitrophyre to hyalopilitic, containing phenocrysts of plagioclase (andesine), hypersthene, hornblende, biotite and augite (enumerated according to the relative amount of the given mineral in the rock). The red lava is characterized by the following peculiarities: 1) brokenness of the porphyry-like phenocrysts, especially of the feldspars, possibly as a result of the resistance this lava met with on its way from the part of the black lava fragments, and 2) high degree of decomposition of the hypersthene phenocrysts, accompanied by the formation of brown and red ferric oxides, beginning with the borders of its crystals.

Aside from microscopical investigation, Dannenberg subjected the black and red portions of the lava to an individual chemical analysis. The results of the latter are given in columns 1 and 2 of the table.

	1	2	3	4
SiO_2	67.80	65.75	67.35	67.06
TiO_2	—	—	0.76	0.74
Al_2O_3	16.92	18.38	15.17	15.41
Fe_2O_3	1.05	2.00	1.74	3.51
FeO	1.94	1.30	2.17	0.57
MnO	0.35	0.20	0.07	0.06
MgO	1.31	1.52	1.80	1.85
CaO	3.25	3.70	3.54	3.60
Na_2O	4.36	4.04	3.94	4.02
K_2O	3.35	4.11	3.34	3.05
P_2O_5	—	—	0.32	0.32
H_2O,—110°	0.33	1.20	—	0.08
H_2O,+110°			0.11	0.07
	100.66	102.20	100.31	100.34

As one may see, the similarity here is also rather considerable. The chief distinction consists in the prevalence of the red variety of ferric oxide over ferrous oxide, and in a higher content of volatile components.

Schlieren-breccia-like rocks, similar to those investigated by Dannenberg, have been somewhat later described by Schafarzik (8) from Dechy's collection: 1) breccia-like red lava, with enclosed fragments of black rock from the moraine of the Asau glacier, and 2) banded lava from alternating red and black beds, from the moraine of the Terskol glacier.

In his description of the «North-eastern foothills of Elbrouz», A. P. Gerassimov (3) pursued the characteristics of spotted banded Malka lavas undertaken by Dannenberg. The picture he gives is about the same, though the materials used up by both investigators were rather different: Gerassimov was working with hypersthene dacite from the oldest of the lower flows of Elbrouz eruptions, while Dannenberg had recourse to hypersthene-amphibole dacite, presumably from the younger lava flow from the left-hand bank of the Malka river.

In the porphyry-like phenocrysts used by Gerassimov are prevailing plagioclase and hypersthene, while biotite, amphibole and monoclinic pyroxene are playing quite a subordinate rôle. The plagioclase of the pheno-

crysts—labrador-andesine with an average composition Ab_1 An_1, in part slightly zonal; hypersthene with 2 V from—56° to—75°, which points to the variability of the FeO content; the lath plagioclase of the hyalopilitic ground mass—of oligoclase group. The brokenness of the phenocrysts and the accumulation of free ferric oxides (brown hydroxide, according to Gerassimov) in the red portions of the lava—similar to that observed by Dannenberg. Contrary to the latter author, A. P. Gerassimov supposes that the «variegated spotted lavas present no breccia, but a product of a peculiar magma differentiation», in the course of the solidification and crystallization of the latter. Some additional data on the primary occurrences of the banded lavas described by Schafarzik are given by Dubiansky ([4]).

This summer, while taking part in a small excursion to the foothills of Elbrouz from the side of the Baksan river, we had the opportunity of observing beautiful specimens of breccia-like and banded lavas from this volcano among the boulders of the Baksan valley near the village of Tegenekli. They are evidently of Terskol-Asau origin. Our attention was attracted by their general appearance, which fully corresponded to Dannenberg's description, and we subjected them to a special investigation. The results obtained by us complete the data by Gerassimov and Dannenberg as shown below.

As may be deduced from the above quotation of Dannenberg's work ([5]), the same idea, though in a somewhat different interpretation, being emphasized by Gerassimov ([3]), among the breccia-like and banded lavas of Elbrouz there exist neither structural nor genetical contradistinctions. However, in so far as the relation between the red and black portions of these lavas stand out more sharply in their breccia-like varieties, we thought it wise to focus our attention on the latter.

Under the microscope the black portions in the thin-section look as more or less normal cryptodacites ([1]) with a light-brown hyalopilitic ground mass and with porphyry-like phenocrysts of plagioclase, hypersthene, amphibole, biotite, etc. All this agrees fairly well with the descriptions by Gerassimov and Dannenberg. The only striking feature of our preparation is the total absence in them of quartz, reported by the above authors, instead of which we stated the presence of cristobalite, forming alongside of glass screen-like inclusions in larger plagioclase phenocrysts.

Judging by their microscopic structure, the red portions, enveloping the fragments of black cryptodacite, are nothing else than cryptodacites either; they possess, however, the following peculiarities which failed to be given full attention neither by Gerassimov, nor by Dannenberg.

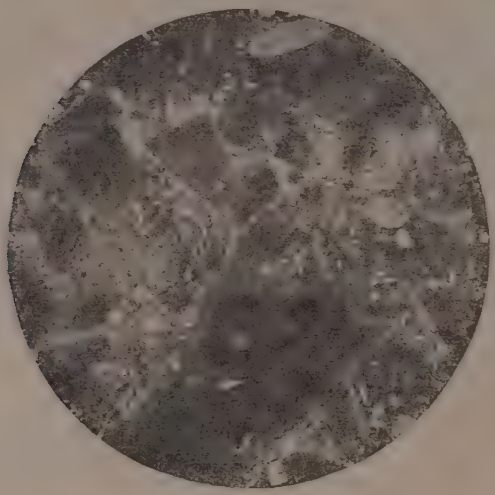
1. Clastic structure, at the expense of crushing and partial translocation of fragments not only of plagioclase and hypersthene, but also of the ground mass of the rock.

2. The disappearance of glass in the fragments of the former hyalopilitic ground mass, due to crystallization, which results in the general coloration of the rocks becoming lighter.

3. The products of the above crystallization are very thin and do not act upon polarized light; in common light they give occasionally the impression of intergrowth of KaNa feldspar and cristobalite. Unfortunately, all these phenomena being rather disperse, they refuse examination by means of immersion, and we were successful to identify accurately only cristobalite (refraction $N = 1.486$), since the latter develops sometimes into continuous accumulations and larger individuals.

Very curious seemed to us the pseudomorph of cristobalite we met once. It possessed a typical lanceolate tridymite twin, which is a phenomenon that should be especially emphasized, as being rather surprising if compared

with the diagram of SiO_2 inversions, developed by Fenner in 1913 (6). Indeed, there is hardly any doubt that crystallization proceeded in our lavas at temperatures considerably below 1470°, which Fenner pretends to be that of the inversion α-tridymite⇄α-cristobalite. However, within this range of temperatures, according to the mentioned diagram, the relative stability of cristobalite is shown to be lower than that of tridymite. Thus, the inversion of the latter mineral into the former one seems out of question. The impossibility is, however, overcome in the given case. We are, therefore, inclined to believe that Fenner's diagram, whose middle parts have not been critically reviewed since 1913, requires experimental revision.



4. The development of haematite laminae which proceeds along with that of colourless small crystals within the texture of the rock at the expense of the primary magnetite dust; hypersthene becomes red (haematized) which according to the authors quoted above seems to be due to its oxidation.

As may be deduced from the above stated, the red portions of the breccia-like lava form the more mobile medium, its black insular portions are floating in. Though the boundaries between both are rather clean-cut, the borders of the black islets are usually altered owing to contact. This alteration is usually manifested in their reddening, that can be macroscopically observed, while, when observed through the microscope, their thin-sections look lighter (figure). The thickness of the contact zones is variable; it may reach ½ mm, so that the smallest islets suffer total alteration. In larger islets lighter ramifications of the same nature are stretching out from the red contact zone into the rock; sometimes closed light areas are formed within the rock proper, owing to which the latter looks spotted. Having assumed the colour of the red areas, the contact zones of the black lava undergo at the same time a number of mineralogical transformations (disappearance of glass, cristobalite). Mechanical alterations as crushes and shifts, on the other hand, are totally absent. Porphyry-like phenocrysts are quite intact, as well as the fluidal flows of feldspar microlites within the ground mass.

The relation between black and red areas (bands) in the banded lavas is essentially the same as in the massive breccia-like lavas described above. However, the mechanical character of the contacts is in this case more pronounced, being due to a more vigorous motion of the red areas, which had been cutting in a secondary way the primary contact borders of the black lava masses.

We have quoted above some chemical analyses of black and red lavas, made by Dannenberg. These analyses do not seem to us quite adequate. One of them is obviously deficient (total 102.20). Moreover, we fail to realize why, most figures being rather in close agreement in both analyses and the totals of SiO_2 and Al_2O_3 being nearly the same, the respective values are in one case $SiO_2=67.80$ and $Al_2O_3=16.92$, $\sum=84.72$, while in the other case it is $SiO_2=65.75$ and $Al_2O_3=18.38$, $\sum=84.13$. Besides, the considerable difference of loss on ignition does not follow from our microscopic examination (0.33 and 1.20).

Taking into account all the above said, K. P. Sokova, of the Chemical Laboratory of the Geological Institute of the Academy, undertook at our request a new chemical work, involving separate chemical analyses of the red and black portions of the breccia-like lava. For the results see columns 3 and 4 of the table. We become first aware of a total disappearance of all the discrepancies of Dannenberg's analyses, and, secondly, both rocks prove to be chemically identical, except but for the degree of oxidation of iron, which is slight in the black lava (magnetite, hypersthene), while in the red one it attains almost limit figures (haematite). The latter phenomenon becomes most obvious in both analyses when recalculating the total amounts of Fe_2O_3 and FeO into molecular equivalents of FeO:

Dark portion . .	$1.74 : 80 = 0.0217$	Light portion . .	$3.51 : 80 = 0.0439$
	$2.17 : 72 = 0.0301$		$0.57 : 72 = 0.0079$
	0.0518		0.0518

The data obtained by us on the microscopic and chemical properties of the banded Elbrouz lavas permit us of reconciling the statements of Gerassimov and Dannenberg as to the origin of these lavas. Indeed, Dannenberg shows them to have been formed not as a result of differentiation, but as a consequence of the older black lava having been captured by the red one; Gerassimov, on the other hand, assumes them to be neither breccia, nor combination of two lavas, but nothing else than a «product of a peculiar differentiation», taking place in the course of both solidification and crystallization of one single lava. The data collected by us seem to support on one side the view of Dannenberg (genuine breccia), on the other one, that of Gerassimov (breccia being formed, as a matter of fact, at the expense of one lava). The breccia-like lavas seem to have formed as a result of crushing of the almost solid but still hot lava flow during its motion; gas (or air currents), captured by this flow and producing its partial oxidation, have also vigorously contributed to this process. In the course of oxidation of certain portions of the lava flow their temperature rose, the viscosity became reduced, possibility being thus created both for additional motion and additional microcrushing, and, moreover, for still ungasified masses to be carried away by the new formed microbreccia into the macrobreccia-like lava.

Most typical is the crystallization of silicate lava glass, which accompanies this process, with liberation of silicic acid in the form of the mineral cristobalite (tridymite). Thus, cristobalite, which is known to be wide

spread among the lavas of the Caucasus and Transcaucasia (2), proves to by also present in the Elbrouz lavas, though it had never been reported in this connexion by previous investigators.

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ENGINEERING GEOLOGY

MOVEMENT OF GROUND-WATERS IN INTER-RIVERING TRACTS

By G. I. KAMENSKI

(Communicated by A. D. Arkhangelsky, Member of the Academy, 16. X. 1938)

In course of the process of infiltration of atmospheric precipitation the ground-water table in an inter-riverine tract of land assumes the shape of a curve, whose investigation permits of solving a number of problems of practical interest connected with the percolation of water from reservoirs through watersheds and also with the banking-up of ground-waters (1, 2, 3). Percolation through the water-parting may arise,

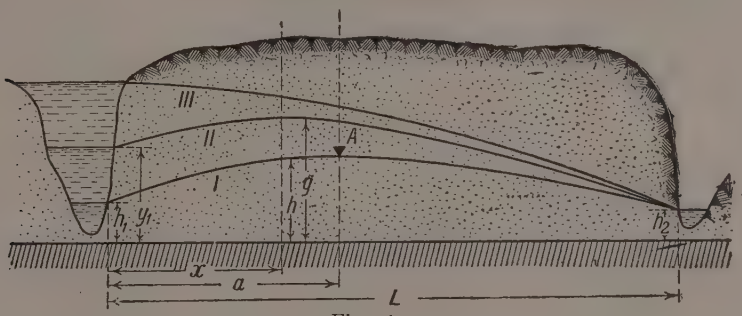

Fig. 1.

for instance, in course of the erection of a dam on a river separated from another one lying at a lower level by a but narrow watershed, or else, when we deal with the case of a dammed-up river separated from its lower course by not to broad a bend (as this is the case in the region of the Kuybyshev hydroelectric scheme). For any section of the underflow in the inter-riverine tract (Fig. 1) we may write:

1) for the left-hand side of the tract

$$q = kh \frac{dh}{dx}, \qquad (1)$$

2) for the right-hand side

$$q = -kh \frac{dh}{dx}, \qquad (2)$$

where q is unit consumption of underflow, k — coefficient of percolation, h — the level of ground-waters measured from the horizontal base of the water-bearing layer, x — distance from left-hand river.

The consumption of the underflow may be expressed in another way in the terms of the feeding of the underflow by infiltration of atmospheric precipitation:

1) for the left-hand side of the inter-riverine tract

$$q = w(a - x), \qquad (3)$$

2) for the right-hand side

$$q = w(x - a), \qquad (4)$$

where w is the value of infiltration, i. e. the layer of water seeping through from the top per unit of time, and a is the distance from the river to the watershed.

Equalizing the right-hand parts of equations (1) and (3) and (2) and (4), we obtain for both the left and right-hand sides of the inter-riverine area the following common differential equation:

$$kh\frac{dh}{dx}+wx-wa=0. \tag{5}$$

After dividing the variables and integrating the latter within the limits from the initial datum mark at the level of the river up to the datum mark at distance x from the level, we obtain:

$$h^2=h_1^2+2\frac{w}{k}ax-\frac{w}{k}x^2, \tag{6}$$

where h_1 is the level of ground-waters at the datum mark of the river.

Equalizing in the obtained equation $x=L$ (or the breadth of the whole inter-riverine tract) and assuming $h=h_1$ (the level of water in the other river), let us find the distance to the watershed:

$$a=\frac{L}{2}-\frac{k}{w}\frac{h_1^2-h_2^2}{2L}. \tag{7}$$

Substituting this value of a into equation (6), we shall obtain the following equation for the curve of the depression of ground-waters in the inter-riverine tract:

$$h^2=h_1^2+\frac{w}{k}Lx-\frac{h_1^2-h_2^2}{L}x-\frac{w}{k}x^2. \tag{8}$$

The problem of percolation through the watershed may be decided if the position of the watershed of ground-waters with the banking-up of the river is determined, which may be done on the basis of equation (7). If $a>0$, then, with the banking-up of the river there will be a water-parting of ground-waters and no seepage from the reservoirs will be available. With $a=0$, we shall have a critical position of the water-parting which will be on the bank of the dammed river. With further increase of the level of water in the latter, percolation from the reservoir will set in, proceeding in one direction, namely towards the downstream course. The critical situation of reservoir level, h_1', may be determined from formula (7) with $a_1=0$:

$$h_1'=\frac{w}{k}L^2+h_2'. \tag{9}$$

The magnitude of $\frac{w}{k}$ may be directly calculated from data on the amount of percolation of the water-carrying capacity of local rocks, else from equation (8) by substituting water level h_n in the stead of h in any well, located near the reservoir at distance x_n from the datum mark of the reservoir. For determining the consumption of the underflow running from the banked-up reservoir into another catchment basin, let us write the equation of the underflow, taking into account that at any given section at a distance from the reservoir the consumption of underflow q_x will be composed of seepage into the banks of the reservoir having consumption q_1 and the percolation of atmospheric precipitation wx, added up to the underflow during its passage along path x:

$$q_x=q_1+wx. \tag{10}$$

Substituting in the stead of q_x its magnitude out of Dupuy's differential equation, we have:

$$-kh\frac{dh}{dx}=q_1+wx.$$

Upon division of the variables and integration of the latter equation within from the initial section at the level of the reservoir and up to section at distance x from the level, we obtain:

$$h^2 = h_1^2 - 2\frac{q_1}{k}x - \frac{w}{k}x^2. \qquad (11)$$

Assuming that in this equation $x = L$ and $h = h_2$, we obtain the following expression for q_1:

$$q_1 = k\frac{h_1^2 - h_2^2}{2L} - w\frac{L}{2}. \qquad (12)$$

Formulae (11) and (12) are a more generalized expression of underflow consumption than the well-known formula of Dupuy. The latter is obtained from these formulae as a particular case with $w = 0$.

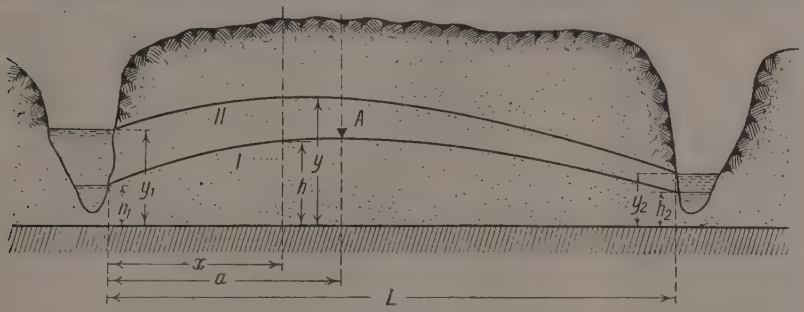

Fig. 2.

With reference to formula (12) the question of filtration over the watershed will be determined by the following consideration. Depending on the relation of the values of equation (12), there may be the following possibilities:

$$1)\ q_1 > 0, \quad 2)\ q_1 = 0, \quad 3)\ q_1 < 0.$$

In the first case, we have seepage from the reservoir; in the third case, the opposite takes place, i. e. the reservoir is fed by ground-waters, while the second case is an intermediate position, when seepage from the reservoir, as well as the feeding of the latter by ground-waters equals zero. Formula (12) may be used for the determination of the rise of the ground-water level with banking-up (Fig. 2), for which case we can write two equations:

1) prior to banking: $h^2 = h_1^2 - 2\frac{q_1}{k}x - \frac{w}{k}x^2$;

2) after banking: $y^2 = y_1^2 - 2\frac{q_1'}{k}x - \frac{w}{k}x^2$.

Subtracting the first from the second, we obtain:

$$y^2 - h^2 = y_1^2 - h_1^2 + 2\frac{x}{k}(q_1 - q_1').$$

Making good use of formula (12), we determine the value of magnitude $q_1 - q_1'$, which characterizes the change in underflow consumption at the side of the reservoir:

$$q_1 - q_1' = \frac{k(h_1^2 - h_2^2) - (y_1^2 - y_2^2)}{2L}. \qquad (13)$$

After substituting this expression into the preceding equation and making transformations, we finally obtain the following formula for the new location of the ground-water level at the point under consideration:

$$y^2 = h^2 + (y_1^2 - h_1^2)\frac{L - x}{L} + (y_2^2 - h_2^2)\frac{x}{L}; \qquad (14)$$

k and w have here been cancelled, as we assume the structure of the layer to be homogeneous and the percolation unchanging.

Equation (14) holds with a rise in the levels of the rivers on both sides of the tract of land under investigation. But more usual under practical conditions will be banking only on one side of the tract, i. e. when $y_2 = h_2$. In this case the last member in the right-hand side of equation (14) will disappear and we obtain:

$$y^2 = h^2 + (y_1^2 - h_1^2)\frac{L-x}{L}. \qquad (15)$$

Formula (14) is applicable also in the case when in the banking zone beyond the section investigated there will be located a tidal creek or a ravine in which the level of ground-waters prior to banking stood below ground level. If after banking the ground-waters at this place will rise to the surface of the ground, the ravine or creek in question will be apt to drain them, taking the part of, as it were, a second river and reducing somewhat the amount of banking. In this case calculation according to Dupuy's standard formula gives an exaggeration and the level of ground-waters calculated from it after banking will be found to stand above ground surface. In this case, in making our calculations, we take for value h_2 the level of ground-waters under the floor of the ravine before banking, for y_2 — the height of the possible rise of the same level in the ravine, i. e. the elevation of the ravine floor above water-stop, for L — the distance from the river to the ravine.

In case if, in result of banking, the datum marks of the river-sides become shifted, the formulae must be somewhat modified. But they can also be used without any change, by means of measuring water level h before banking at the sides of the future reservoir, where a special well is sunk for the purpose. Distances x and L are in this case measured from the well in question.

If we assume in equation (15) that $\frac{L-x}{L} = 1$, which holds for the case when L is very great as compared with x, then equation (15) will pass into Dupuy's calculation formula for the banking of ground-waters:

$$y^2 = h^2 + y_1^2 - h_1^2. \qquad (16)$$

Formulae (14) and (15) were deduced in a somewhat different way by T. M. Vasilishin who, while making use of a filtration trough, showed their great accuracy. We have carried out control calculations for the valves of test-wells sunk in Moscow, and these calculations have likewise given fully satisfactory results.

In conclusion we wish to state that the formulae described above, while establishing a definite dependence of the form of the ground-water table upon the kind of structure and drainage available in the interriverine tract, may thus serve as a theoretical basis for a hydrogeological investigation, having for its purpose to ascertain the conditions of percolation and banking of ground-waters at the site of a hydrotechnical scheme, and may even sometimes give a direct quantitative solution of the problems involved.

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GENETICS

ANALYSIS OF THE CHROMOMERE STRUCTURE OF MITOTIC CHROMOSOMES IN RYE

By E. N. SHMARGON

(Communicated by N. I. Vavilov, Member of the Academy, 2. X. 1938)

The chromosome morphology in modern cytology has been based chiefly on the study of the size and structure of the chromosomes: primary differentiation of the chromosome into two arms, and secondary—division of each arm into two or three more or less definite segments. Recently, however, investigations of chromosome morphology have advanced in the direction of finding out the more minute and detailed structure of chromosomes. In *Crepis capillaris* (1), by fixation with modified Flemming's solution containing a smaller amount of acetic acid, and particularly in *Allium Cepa*(2), by growing in sawdust and fixation with Champy's solution, it proved possible to obtain very distinct pictures of the so-called «chromomere» structure of mitotic chromosomes. In *Allium Cepa*, moreover, one chromosome has been thoroughly analyzed and it has been shown to contain over 20 chromomeres, well differentiated in size and position. As compared with the chromomeres at meiosis, those of mitotic chromosomes are regarded as «compound» ones, being formed as the result of the fusion of the «ultimate» chromomeres(8). By the present investigation we proceeded to an analysis of the chromomere structure of mitotic chromosomes in rye. By using the above method of planting the seeds in moist sawdust and by fixing the material with Lewitsky's «strong platinic formalin» solution (3,4), it proved possible also in rye to make out minute peculiarities in the structure of the chromosomes. Positive results were also obtained by using Champy's method of fixation. Microtome sections 16 microns thick were stained with iron haematoxylin. Staining may also be done by Feulgen's method or with gentian-violet, but the structural peculiarities of the chromosomes fail to be brought out in such sharp relief as when iron haematoxylin is used for staining. In order to bring out the chromomere structure even with the method adopted by us, it is necessary to secure fairly good differentiation in staining, since otherwise the chromosomes will appear uniformly structureless. Moreover, the chromomeres are sharply defined only during the periods between prophase and early metaphase and between late metaphase and late anaphase. When the staining is sufficiently differentiated, the chromomere structure is well defined along the entire chromosome. There is sometimes seen around each chromomere a very slightly stained «sheath», the outer boundaries of which apparently coincide with the original contours of the chromosomes. This phenomenon is essentially analogous to that of the contours of the matrix at the time of the appearance of the spiral structure of the chromosomes at meiosis(5).

In order to facilitate the study of the chromomere structure of the chromosomes, prior to fixation the material was subjected to low temperature (24 hours at 0°), which caused the chromosomes to contract and straighten out.

In Fig. 1 is shown a metaphase plate, in which almost all the chromosomes show chromomeres. In the somatic set of rye, with our method of treatment of the material, the chromomere structure of most of the chromosomes was quite well defined. In the present paper we shall give a detailed description of the «appendage» bearing chromosome, as the one possessing a most distinct morphology characterized by the presence of the «appendage» and the relation to the nucleolus. In the idiogram this chro-

Fig. 1. *Secale cereale*. Metaphase chromomere structure of chromosomes. × 1000

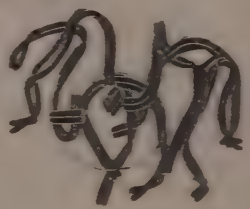

Fig. 2. *Secale cereale*. Late prophase of first division in a pollen grain. Chromomere structure not represented. Shows connexion of chromosome having «appendage» with nucleolus. × 2000

mosome ranks fifth as regards length[4], but owing to the variation in the length of the achromatic zone connecting the «appendage» with the chromosome it may possibly occupy a different place. Thus, according to G. A. Levitsky's data[5], it takes second rank. At prophase this chromosome is connected at the point of the achromatic zone with the nucleolus. This is particularly well expressed in the first division of the pollen grain (Fig. 2), and is analogous to what has been observed in maize[6]. Together with the «appendage» the chromosome is almost equal-armed (is abrachial) (Fig. 3, *a*). Owing to the achromatic zone, the «appendage» keeps apart from the main body of the chromosome and is so large that it may be well seen irrespective of the method of fixation employed.

Fig. 3 gives several views of the chromosome with the «appendage», showing its chromomere structure. In Fig. 3, *b* the chromosome is taken from a nucleus at late prophase. In this case the chromomeres are sufficiently spaced, and the bead-like structure of the chromosome is clearly observable. The same holds true for *c*, *d*, *e*, *f*, *g*, *h* and *i*, where the same chromosome is taken from a nucleus at the metaphase (in the case of *c*, at the metaphase of a nucleus from a root-tip fixed by Champy's method). Chromosomes *d* and *e* are homologues taken from the same plate (Fig. 1); the chromomeres in them are, however, not equally well defined, which may, presumably, be referred to the technical peculiarities of iron-haematoxylin staining. In Fig. 3, *j* the same chromosome is shown at anaphase. From all figures it is evident that the chromosome investigated consists of eleven chromomeres. Six of them form the long arm, three the short one and two the «appendage», thus showing that the finer structure of the chromosome is constant.

We studied the same chromosome at meiosis during the pachytene stage, where it could be identified thanks to its connexion with the nucleolus. Rye

spikes were fixed with a 3:1 solution of alcohol and acetic acid and kept in 70% alcohol; for investigation the anthers were crushed under a cover-glass in aceto-carmine. According to preliminary calculations, the number of «ultimate» ([8]) chromomeres in the investigated chromosome is about 50

Fig. 3. *Secale cereale.* Chromosome with appendage. Explanation in text; x 4000.

(Fig. 4). In the section of the thread adjoining the nucleolus may be seen the «nucleolar organizing body»([7]). From all the data published on the position of this «nucleolar organizing body», it may be concluded that the chromomeres located beyond this body belong to the «appendage». If this be the case, the «appendage» consists of six «ultimate» chromomeres.

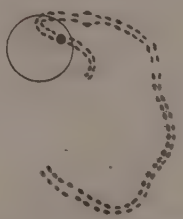

Fig. 4. *Secale cereale.* Chromosome with appendage at the pachytene stage: x 2000.

In a mitotic chromosome we have to do with compound chromomeres formed as a result of the fusion of groups of chromomeres into separate chromatin «packets» during the contraction of the chromosome. In the given case the number of such «packets» or «compound» chromomeres in the mitotic chromosome investigated is eleven. The size of the chromomeres in the appendage varies: sometimes the distal one appears the larger (Fig. 3, *b*, *c*, *f*), at other times the proximal one (Fig. 3, *d*, *e*, *h*, *j*). This may be explained by the presence between them of a small chromomere (Fig. 3, *k*). Depending upon which one of its neighbours it fuses with, now the peripheral, now the inner chromomere increases in size.

In the present investigation we are for the time being confining ourselves to the determination of the chromomere number. Although their individuality was noted in some cases, the observations were scarce, and the solution of this problem constitutes the task of a subsequent investigation. But the very fact that the number of chromomeres is constant is of great interest. Availing of adequate methods of bringing out the structure details, it will prove possible to identify chromosomes simply by counting chromomeres instead of laborious measurements with the aid of the micrometer screw. Moreover, change in the number of chromomeres may be useful in detecting changes in the chromosome structure. The most accurate analysis of structural changes in chromosomes is possible only in case of a complete individualization of the chromomeres, as it is the case in the investigations of the chromosomes in the cells of the salivary glands of *Drosophila*.

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GENETICS

CAUSES OF CONSTANCY IN THE CHROMOSOME NUMBER OF THE AUTOTETRAPLOID *NICOTIANA SILVESTRIS* VAR. [illegible]

By P. A. POVOLOCHKO

(Communicated by N. I. Vavilov, Member of the Academy, [illegible])

The production of polyploid plants by treating somatic cells with growth hormones, such as [illegible] [1], heteroauxin [2], acenaphthene [3] and colchicine [4], does not present special difficulties. The efficiency of treatment by these substances is such that the problem of polyploidy may definitely be considered as solved. However, earlier investigators who studied amphidiploid plants paid attention chiefly to the fertility and insufficiently considered the degree of constancy. Artificially produced polyploids, as a rule, give aberrant progeny, and are not always, even morphologically, constant [5]. The reason for this lies in irregularities at meiosis, such as various degrees of chromosome conjugation and the formation in pollen mother-cells of quadrivalents, trivalents, and univalents [6].

The autotetraploid *Nicotiana silvestris* var. *[illegible]*, obtained by us in 1935 [7], was normally fertile. Seeds obtained by open pollination were sown in 1936—37, both in the field on the [illegible] State Farm and in the greenhouse at [illegible]. Mature plants under field conditions developed uniformly and exhibited no perceptible variations in the size of the flowers and leaves, height of stem, or of other morphological characters. Under field conditions the general development of these autotetraploid plants was considerably more vigorous than that of diploids. Tetraploid plants grown in the greenhouse displayed some variation in the size of the flowers, due in all probability to differences in the conditions of culture, since in the greenhouse the plants were grown in pots. However, this did not in the least affect the plants fertility. In the following year (1937), when seeds obtained in 1936 were sown, the fertility of the plants likewise remained normal.

The pollen grains were investigated during three successive years, both in the tetraploid obtained by regeneration and in its progeny. The pollen was uniform in shape and size, and stained well with aceto-carmine. There was scarcely any abortive pollen, except for occasional abortive grains usually occurring not only in autotetraploid but also in diploid forms.

For the cytological investigation of pollen mother-cells we used both aceto-carmine and smear preparations.

Studying meiosis in this autotetraploid, we found at M_1 12 biscuit-shaped chromosome bodies, indicating the formation of 12 quadrivalents (Fig. 1, a). Besides such plates, there were also encountered some in which the number of bodies ranged from 13 to 24 (Fig. 1, b). By the distribution, shape and size of these bodies it was possible to judge as to the presence of quadrivalents or of quadrivalents split into bivalents. Fig. 1, c shows a plate where

the quadrivalents have split into bivalents, but the latter have not separated to the poles but remain in one plane. Side by side with this plate in the same preparation we found other plates, where the bivalents had in turn split into univalents. Such a plate is shown in Fig. 1, *d*, where there are seen 12 groups of chromosomes. The position and number of chromosomes in each group confirms the quadrivalent nature of all the chromosomes at M_1 in this autotetraploid. The chromosomes in each group are clearly distinct one from another. These univalent chromosomes lie, as a rule, in the same plane as their homologues, while the second pair of the group is usually in another plane, forming a cross with the first pair. This arrangement of the two pairs of univalents is the result of the division of each bivalent. However, even at this late stage the chromosomes do not diverge to the poles.

Somewhat later the univalents separate from their groups. In Fig. 1, *e* is shown a plate, in which some of the groups are still in their original position, consisting of four closely contiguous chromosomes, while in the rest of the groups some of the chromosomes have scattered and constitute separate univalents not closely connected with the other chromosomes.

Neither the division of the quadrivalents into bivalents nor the subsequent division of the bivalents into univalents occur simultaneously in every case. Often plates are found, in which some quadrivalents have divided into bivalents, while others have not yet divided (Fig. 1, *f*). A similar phenomenon is observed also in later stages, when the bivalents split into univalents. Fig. 1, *f* shows a plate, in which eight of the quadrivalents have undergone two successive divisions, i. e. into bivalents and then into univalents. Some of the univalents belonging to these eight groups are already beginning to separate from their respective groups, while the other four quadrivalent groups have divided only into bivalents.

The indicated delay is apparently not of long duration. At later stages of M_1 all the chromosomes have divided and constitute independent univalents to the number of 48, which are distributed in the equatorial plane, ready to diverge to the poles (Fig. 1, *g*), since the passes of division of the quadrivalents into bivalents and then into univalents have already taken place in an earlier stage of M_1.

However, during our investigation of meiosis in pollen mother-cells we found one cell, in which two bivalents had failed to split into univalents at M_1 and divided only at anaphase (Fig. 1, *h*). The univalent chromosomes of this cell separated to the poles, while the two bivalents remained at the stage of splitting.

At M_2 (Fig. 1, *i*) there are always 24 univalents in each plate: not in a single case did we find a plate with any other number.

[illegible] at the reduction division homologous chromosomes of each type separate and are distributed to the gametes, forming all possible combinations [illegible]. When such is the course of the reduction division, the presence at M_1 of quadrivalents leads to irregularities in the division and separation of the divided quadrivalents to the poles, as a result of which abortive pollen grains are formed. But in the case of the autotetraploid *N. silvestris* var. *Egb*[illegible] the presence of quadrivalents at M_1 does not cause irregularities during the reduction division.

At M_1 the chromosomes of the autotetraploid form an equatorial plate of 12 quadrivalents, which undergo two successive divisions into bivalents and univalents. However, the splitting of the quadrivalents is not immediately followed by separation to the poles. The chromosomes remain in the equatorial M_1 plate until they have all split into univalents, and only after all the chromosomes are separated one from another do they pass to the poles. The fact that some quadrivalents lag somewhat behind in splitting into bivalents and then into univalents apparently has no significant effect, since it seems to cause no irregularities in the general course of the reduction division.

The regular splitting of the quadrivalents into bivalents and then into univalents and the separation of the latter to the poles ensure the formation of normal viable gametes, each having 24 chromosomes. Chromosome counts at M_1, as well as chromosome counts in the somatic cells of plants of subsequent generations and of some hybrids confirm the constancy of the chromosome number in the gametes.

Conclusions

1. The autotetraploid *N. silvestris* var. *Egb*[illegible] forms 12 quadrivalents at M_1.

2. These quadrivalents at M_1 split successively into bivalents and univalents.

3. Passing of the chromosomes to the poles begins only after all the univalents have separated one from another.

4. Splitting of bivalents at metaphase or anaphase of the first division was not observed.

5. The course of the reduction division in the autotetraploid *N. silvestris* var. *Egb*[illegible] is regular. The number of chromosomes in the gametes is 24.

6. The difference between the character of the reduction division in the autotetraploid *N. silvestris* var. *Egb*[illegible] and that usually observed in other species of plants ensures constancy of chromosome number in subsequent generations.

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PHYTOPATHOLOGY

VIRUS OF TOBACCO-MOSAIC TESTED FOR ITS POWER OF FERMENTATIVE ACTIVITY

By V. L. RISCHKOV and K. S. SOUKHOV

(Communicated by N. I. Vavilov, Member of the Academy, 10 X 1938)

The following reasons urged us to ascertain by experiment whether pure virus of tobacco-mosaic is endowed with fermentative ability.

1. As the action of ferments is found to suffer deap changes in plants attacked by virus disease (for literature see Rischkov), there arises the question should this fact be put down to the influence of virus upon the plant or else might be interpreted in terms of an immediate fermentative activity of the virus.

2. Schuler has established that purified bacteriofagus acts as phosphotase. It is a question of importance whether other filtrable viruses are endowed with a similar action.

3. Many authors, beginning with Woods, have been supposing the virus to be a ferment, and at last the absence or presence of enzymes in the virus should essentially determine our notion as to the nature of virus.

In all our experiments on tobacco-mosaic we failed to detect any fermentative activity of virus as it may be seen from the rather detailed account we are giving below.

Almost every of the experiments, in which the virus was tested for the presence of ferment, was followed by control test under the same conditions, except for the virus under test being replaced by a ferment, in order to prove that the process we failed to observe in the presence of virus should take place if a ferment were acting in the given conditions. As a matter of fact, we invariably observed fermentative activity in the control tests.

O x y d a s e and P e r o x y d a s e. One drop of guaicum dissolved in alcohol was added to ten drops of virus solution* which thereupon did not turn blue. No colouring either was noticed after addition of one drop of 1% H_2O_2 solution. Yet one drop of amaranth juice suffices to produce blue colouring. Experiment was performed with pH = 7.

R e d u c t a s e. Three drops of methylene blue solution (1 : 20 000 moles) and one drop of formalin (dissolved in the ratio of 2 drops of 40% formalin to 10 cm³ water) were added to 10 drops of virus solution (pH = 7.5). The mixture was kept at 60—62° C for one hour, and then at 69—70° C for 20

* The solution always contained about 0.5% protein virus of tobacco-mosaic purified according to Rischkov and Gromyko.

minutes. The methylene blue did not lose its colour. For comparison sake the same solution of methylene blue was added to phosphate buffer solution with pH = 7. 4, in the presence of the respective amount of formalin. The experiment protracted up to 24 hours at room temperature ended with no decoloration of methylene blue. Yet the latter was rapidly fading when raw milk replaced the virus, all other conditions being equal.

C a t a l a s e. A drop of virus on the slide was overlaid with the cover glass and put under the microscope. After one drop of 1% H_2O_2 solution was added to it, no production of oxygen bubbles could be noticed. Yet abundant production of oxygen bubbles was even macroscopically observed under the same conditions when a drop of fresh amaranth juice was added to the peroxide of hydrogen.

A m y l a s e. 12 drops of virus solution were added to 2 cm^3 of 1% solution of starch in phosphate buffer. pH of the mixture 4.5—5. Toluene being added to the mixture the latter was left to stand at 22°C for 24 hours. Then it was tested for the presence of sugar by means of Felling's solution which test gave negative results. The control experiment was made with saliva instead of virus. There boiling with Felling's solution resulted in considerable reduction of cuprous oxide.

In another experiment virus acted in co-operation with boiled tomato juice used as co-ferment. No hydrolysis of starch took place.

P r o t e a s e s. A series of experiments with varying pH (and all with negative results) had for object to answer the important question whether the virus of tobacco-mosaic is able to break down host's proteins, at the expense of which disintegration products it could possibly build itself up. To detect the action of proteases we used fresh prepared bits of fibrin stained according to pH of the medium, either with ammonia carmine or Kongo-rot. A liquid with such a bit immersed in it turned red in the presence of protease. The experiments were performed as follows.

1. 2 drops of virus solution were added to 10 drops of 0.1% HCl. The test tube was kept at 38° for 24 hours with no digestion of fibrin taking place, whereas in the test tubes with pepsin its digestion could be observed as soon as after 2 hours.

2. Fibrin and toluene were added to 10 drops of virus solution with pH = 7.5. The mixture kept at 25°C for three days showed no signs of fibrin digestion.

3. Fibrin, toluene and 2 drops of virus were added to 10 drops of 0.02 moles phosphate buffer solution. pH of the mixture 5—5.5. No digestion of fibrin could be detected even after four days.

4. Negative result too was obtained when the experiment was repeated with pH = 5.6—5. 8 and with addition of 4 drops of boiled tomato juice, the mixture being left to stand at 33°C for 24 hours.

5. The experiment with pH = 5.6—5.8, repeated two times more, gave no positive results either.

6. Similar experiment with glycocoll buffer (pH = 4.6—4.8), repeated twice, answered in the negative.

C h l o r o p h y l l a s e. Chlorophyl extract from dahlia leaves in 70% ethyl alcohol was divided into two equal parts. One half of the extract was left without change while the other was boiled. Into 5 cm^3 of the boiled extract there were introduced 5 drops of virus; into the control, 5 drops of water. All the extract samples were kept in the dark at room temperature not below 15°C during two days. After two days both the control and the experimental extracts were put on slides into weakly moist chamber according to the procedure recommended by Molisch. 24 hours later the preparations were studied under the microscope. In 5 test preparations not a single crystal

of ethyl chlorophyllide could be seen, though they were abundant in the unboiled control.

Asparaginase. Toluene and 4 drops of virus solution were added to 2.5 cm^3 of 0.1 moles solution of asparagine in 0.02 moles phosphate buffer, pH = 7.5. 24 hours later the cover glass with a drop of $PtCl_4$ solution hanging from it was placed over the test tube in order to detect ammonia microchemically. No ammonia was found. The experiment was repeated with the same results. Then it was performed again in some modified variants. The virus, for instance, was tested for the presence of asparaginase in glycocoll buffer (pH = 7.8—8) with and without boiled tomato juice as co-ferment. The result was invariably negative. But as soon as toluene evaporated and multiplication of microorganisms was taking place, we did not fail at once to detect the ammonia by the method mentioned above.

Urease. Six experiments with varying pH were performed in glycocoll buffer: pH=7—7.2; 5.6—5.8; 4.6—4.8. The method to detect ammonia was the same as in the experiment with asparagine. Not a single case was recorded where ammonia would form in urea solutions under the influence of virus. Each of the experiments lasted 24 hours, at 32°C.

Phosphotase. In experimenting on phosphotase we enjoyed the consultation with V. A. Engelhardt, to whom we would fain offer our heartiest thanks. A number of experiments were done with calcium hexose diphosphate which was dissolved in glycocoll buffer up to saturation; pH values embraced by the experiments were 3.7; 6.1; 8.2; 8.4; 9.3. PO_4 ions were being detected microchemically by means of NH_4Cl and $MgSO_4$ solutions (this reaction has been described by Molisch). In all cases negative results were obtained.

Besides we set up experiments with active glycerophosphate in glycocoll buffer for pH equalling 8.2 and 6.1. The result was negative in both cases.

Peroxydase, as some other ferments, is known to increase its action in tobacco attacked by mosaic. Whether it is due to indirect action of the virus, affecting plant's metabolism, or to direct activation of peroxydase, was the question we had to solve by experiments in which we tried to activate the peroxydase by virus in autolytical mixtures. To 36 cm^3 of filtered juice of young tomato there were added 40 cm^3 water, 10 cm^3 of 10% pyrogallol solution and 3 cm^3 of 1% H_2O_2 solution. The mixture was stirred vigorously and then divided into two portions of 40 cm^3 each. One portion served as control and to the other there were added 10 drops of virus solution. Afterwards toluene was added and both portions were left to stand at 20—25°C for 24 hours. The experiment was repeated 4 times. The purpurgallin formed was estimated by titration with decinormal $KMnO_4$ solution. This procedure was also repeated 4 times and in result we obtained the following differences between the control and the experiment as regards the amount of permanganate used up:

1) in favour of the control 0.17%,
2) in favour of the experiment 0.43%,
3) in favour of the experiment 2%,
4) in favour of the control 0.7%.

These differences are sure to lie within the limits of the error, and we may say that the virus does not make active the peroxydase.

Following conclusions may be drawn from the experiments referred to.

1. Crystalline protein virus of tobacco-mosaic does not manifest any effect proper to oxydase, peroxydase, catalase, proteases acting with various pH, asparaginase, urease, amylase, chlorophyllase or phosphatase even under such conditions as are most favourable for the activity of the respective ferment.

2. Virus of the tobacco-mosaic is not able to activate the peroxydase.

3. The fact that peroxydase, amylase and proteases increase their activity in plants attacked by mosaic is due to virus influence on the plant rather than to its direct action upon those substances.

4. Virus seems not to possess enzyme systems of its own and not to compare with any of the live organisms known, as well as the way it stores in the host bears no analogy with the assimilation of host's proteins by a parasite.

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ERRATA

In the article by N. V. Nassonov, Member of the Academy, entitled «Morphogenesis Following the Insertion of the Parts of Various Organs under the Skin of the Axolotl» in the C. R. Acad. Sci. URSS, Vol. XIX, No 1—2:

p. 131	line 6	from the top,	for	«hystolysis»	read	«hydrolysis of cartilage»
p. 141	line 11	from below	»	«dead»	»	«heated»
p. 142	line 7	» »	»	«propagation»	»	«proliferation»
p. 143	line 27	» »	»	«activization»	»	«activation»
p. 143	line 13	» »	»	«propagation»	»	«proliferation»

In the article by J. B. Zeldovich and D. A. Frank-Kameneckij «On the Theory of Uniform Flame Propagation» in the C. R. Acad. Sci. URSS, Vol. XIX, No 9

p. 695 $W\sqrt{2p!\,\frac{x}{\tau_m}\frac{1}{\theta_m^{p-1}}}$ read $W\sqrt{2p!\,\frac{x}{\tau_m}\frac{1}{\theta_m^{p+1}}}$

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